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THE ECONOMICS OF INDUSTRIAL MANAGEMENT

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PREFACE

THIS BOOK EMBODIES the results of many years' experience in industry, in teaching, and in research. It is written to serve the needs of the executive in industry as well as those of the student of industrial engineering and management. Most of the examples used to illustrate the principles formulated have been chosen from the authors' practical experience in the organization of industrial enterprises, in the operation of businesses in which they have served at various times as directors, presidents, general managers, and treasurers and in government service both at home and abroad.

The authors are indebted to their many associates in industry and to the members of the staff of the Department of Industrial Engineering of Columbia University for valuable criticisms and suggestions. Special acknowledgment is gratefully given to Professor Robert Teviot Livingston, Executive Officer of the Department of Industrial Engineering. The services are gratefully acknowledged of Professor J. Brooke Willis, of the School of Business, who read and criticized part of the

manuscript; Professor William Jaffe, Mr. Seymour Melman, Mr. Sydney Pollack, Mr. Paul Flatow, Mr. Julian Green, Mr. Lawrence Cohen, Mr. Robert Edward Randell, and Mr. Frederick G. Oess, who checked problem solutions, and Miss Marion Thompson, who typed the manuscript and prepared its many tables.

It is too much to hope that the book is without some errors. The authors will therefore appreciate it if any reader will write them in criticism of any part of the text.

Athens, Vermont WALTER RAUTENSTRAUCH
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INTRODUCTION

THE DAILY PAPERS frequently report the failures, dissolutions, and bankruptcies of various individuals, partnerships, and corporations. Notices of reorganizations are also given, in which those who have claims or debts have agreed to adjustments in the hope that these enterprises may be saved. Accounts of the earnings of successful businesses and notices of dividend payments are also given as indications of well-managed, economically sound organizations. At times all business slows down and widespread economic distress results. Balancing these hard times and depressions are periods of general prosperity in which work is plentiful and earnings high. Periods of war or international tension create deep economic disturbances of far-reaching consequences. Many explanations of, and opinions on, these fluctuating states and conditions of industry have been advanced, and the attempted orderly arrangement and statement of these observations and conclusions constitute the subject matter of *The Economics of Industrial Management.*

Obviously, some of the fundamental problems of business deal with the relation between cost and selling price. Every manufacturer and merchant endeavors to produce or obtain the goods he sells at costs sufficiently below the selling price to offer attractive profits. Therefore, estimating the probable cost to manufacture and merchandise a product and predicting or forecasting its probable selling price are very important factors in the success or failure of a business. It is only within the past quarter century that serious attempts have been made to develop and use rational methods for estimating the costs of production and marketing and for determining the probable markets for goods and the prices at which they might be sold. Only in quite recent years have a few thoughtful men questioned some of the assumptions on which cost estimates are usually founded and challenged the beliefs businessmen generally hold about markets and prices. The depression which began in 1929 materially stimulated some serious inquiries into the whole field of economic thought. Either there were some factors which determine the success of business enterprise that were not taken into account, or the available facts were not interpreted correctly.

This study will attempt to state what is generally considered to be good practice in dealing with the economic problems of specific business enterprises, to inquire into the theories on which these practices rest, and to develop methods of analysis with which to deal more intelligently with the economic problems of a given business.

As compared with the old shop of the nineties, the modern plant is characterized in part by higher investments, in part by more machines and more workers. These represent important changes. But the old shop also had to deal with problems of finance, procurement, and employment. Such problems are now bigger and more complex but they are *not new*. Between the old and the new organization, with respect to these and many other matters, there is only a difference in *degree*.

But, there is a difference in *nature* as far as the function of management is concerned. The modern organization has become so much more complex that a split has developed between the "man who knows" (the one who has a *direct* knowledge of the facts) and the "man who decides" (the one who has the final responsibility).

This difference in nature accounts for the development of entirely new functions (that of controller or industrial engineer, for instance) and of entirely new procedures and principles of organization. In other words, this difference in nature is responsible for the birth and

development of the techniques of "managerial control," the subject of another volume of this series.*

But, managerial control is only one aspect of the question. The other is managerial economics.

One of the objectives of managerial control is efficient economic operations with respect to procurement, production, and marketing. As managerial control relates to both the internal operations of a business and the external relations with other businesses and institutions, so also does managerial economics concern itself with both the internal and external affairs of a business.

It concerns itself with the design and operation of a plant for low-cost production. It also concerns itself with sources of raw materials, domestic and foreign markets, legislation affecting taxation, labor relations, and many other problems of the general economy.

There are thousands of important relations—with commercial and investment bankers, with bondholders and stockholders, with the suppliers and the customers, with the competitors and the public authorities—which must be dealt with.

Such relationships, of course, are not new. The old shop knew them also but their complexity has grown so extensively that, here again, there is a difference in *nature* between the problems faced by the old shop and those faced by the modern plant.

The difference is threefold:

1. Due to the increasing complexity in organization, the old and traditional methods used before are now no longer sufficient for the visualization of the situation as a whole.
2. Due to the increasing size of the investments and to increasing competition, problems such as fixed charges, rate of production, depreciation, labor costs, etc., that were formerly considered as negligible, are today most significant.
3. Due to the increasing influence of general economic conditions on the well-being of an enterprise, management is now compelled to watch carefully the trends in operation of the whole national plant. The old shop had one main problem: to do a fine job so as to please its customers in an essentially local market. By so doing, it was practically certain of being successful and of enjoying a continuous stability. What modern plant manager could think in those terms? Management today cannot ignore

* Now being prepared for publication.

fair and unfair competition, the pressing need for markets large enough to absorb the heavy burden of overhead expenses, the income brackets, the taxes, the purchasing power, the international commercial, and even political, situation.

Economics is now part of the task of management. Economic techniques have been developed and so perfected, especially during the last decades, that anyone who is not a specialist will find it difficult to follow them and to understand their concepts and special terminology.

This book is an attempt to present methods of solution of the daily problems of business in the field of economics. A special effort has been made to enable the businessman or the student who has no special background in economics to follow the discussion easily.

Although the principles developed could be applied to various kinds of businesses, this book is especially intended for the managers of industry and for the students in industrial organization and economics.

With that purpose in mind, the best first approach to the subject seems to be a consideration of the fundamental element of modern industry—the machine.

Every machine has certain functional characteristics, such as adaptability to perform certain operations, range of sizes of work, and the skill required for its operation.

But a machine has also certain economic characteristics. They are the ones studied in managerial economics. What is the cost of the machine—cost to possess, cost to operate, charges for capital recovery? What is the economic efficiency of the machine, as compared to that of other machines available to do the same work?

Functional and economic characteristics are, each, distinct attributes. Many machines have been built, many more will be, that are technically perfect, but economical failures.

But managerial economics not only concerns itself with a machine as a unit—it also relates to a group of machines.

The important fact to keep in mind is that the total value of a group of machines is *not* the arithmetic sum of the capacities of the machines that are part of the group.

This is a very general phenomenon. A group of human beings has a life distinct from its individual components. In the chemical world, $C^6\ H^{10}\ O^5$ is cellulose or is starch, depending on how these isomers have organized their component molecules.

A bridge may fail because of a faulty tower, even if the cables supporting it are ten times stronger than they need be.

Bottlenecks in the flow of work will reduce the attainable efficiency of the best machine to the capacity of the worst—just as, during the war, a convoy had to cross the ocean at the maximum speed of the slowest ship.

Therefore, it is the value of the machine within the group that managerial economics must consider.

This, indeed, is one of the difficulties of the problem.

Just as an individual is, at the same time, a member of his business organization, of his family, his state, etc., so is the machine, at the same time, a part of different groups.

There is a first integration at the level of the department, a second one at the level of the plant.

But, maybe the plant itself is one of a few operated by a large corporation and depending on the others for its supply. The group to consider in such a case is the whole corporation.

In any case, any plant depends on others for its supplies, its equipment, its markets. Different levels of integration should, therefore, be considered. The economic value of a machine will be entirely different if it is considered individually, or as part of a department, or as part of a plant, a corporation, a group of industries, or as part of the "national plant" as a whole. Its individual functional value, meanwhile, will not vary.

What is true for the machine is true for any other economic factor —the buildings, the capital, the profits, the manpower, the product, etc.

Each factor should be considered not only as a unit but as part of a whole.

The problem is further complicated by the variations in the degree of integration.

Within a plant, despite the progress of scientific management, the integration varies from excellent to fair to poor. It even changes with time.

Within a given group of industries, all the nuances of the rainbow of integration can be found. Some industries have gone through an extensive process of integration; some have not yet started. To illustrate, it is sufficient to mention, for instance, the steel industry on one side and, on the other, the manufacture of buggy whips.

Within the national plant as a whole, the integration is more or less dependent on the national policy.

But, whatever the degree of integration, the fact remains that the economic characteristics of a business have to be studied from various points of view.

This book on the economics of industrial management, therefore, is divided in three parts:

Part I—Visualizing the business.
Part II—Industrial cost characteristics.
Part III—The business as part of the "national plant."

I

THE ECONOMIC FLOW CHART

A BUSINESSMAN is an investor. He invests either his own funds or those which others have entrusted to him. Instead of investing in securities and managing a portfolio as the financial man does, he invests in machinery and buildings, and in materials and services of many kinds. He naturally expects to make a return on these investments. The amount of the return he may expect will depend on the relation of the amount invested to its utility in the business; consequently he asks the question: Will it pay to make the contemplated investment in either machinery or buildings or materials or services? Frequently he is confronted with two or more choices, and therefore he asks: Which will yield the most return on the investment? After he has made his decision he is faced with the problem of making the investment pay as anticipated. To do this he must know the facts of the business he is operating and, most important, must know what the facts mean. To interpret the facts of the business he must relate them to a frame of reference.

That is, he must be able to state from the facts, and the relationships among the facts, that either correct or incorrect tendencies exist in the business. We will therefore endeavor to develop methods of analysis upon which good decisions in such matters may be founded.

The directors and officers, the department heads, the minor officials, and the workmen in every business are deciding to do "this" and not "that," and the combined effects of all these decisions determine whether or not the business is operating satisfactorily. If the majority of the important decisions made conform to sound economic principles, the success of the business is assured. The question which this statement raises is: What are sound economic principles in any given case? How may one know the conditions under which a maximum probability of economic success may be attained? Is success in business largely a matter of good fortune or chance, or are there certain principles that must be followed if a business is to be run successfully? It cannot be denied that a certain amount of good fortune has attended many men who are financially successful. On the other hand, it is quite obvious that the probabilities of success through dependence on mere chance are far from promising. It has also been observed that certain men seem to run businesses successfully without the consciousness of having followed definitely formulated economic principles, and their success seems to deny any need for studying the economic principles of business enterprise.

Sufficient evidence has been accumulated to show that all business enterprises have a capacity to conform to some very definite economic behaviors, just as machines have certain well-defined characteristics which may be realized by good operation. The electrical engineer controls the operations of electrical equipment successfully when he understands how it behaves under different uses. The steam turbine operates according to well-known principles of thermodynamics; and, when these principles are conformed to, the turbine will function successfully. So also business enterprises have been found to possess certain well-defined economic characteristics or principles of operation, and it is the province of this study to uncover and understand them.

THE ECONOMIC FLOW CHART IN BUSINESS ENTERPRISE WITH PARTICULAR REFERENCE TO MANUFACTURE

When the electrical engineer begins a study of an electrical machine, he first traces the flow of the electric current through the

machine to find out how it works or functions. His next problem is to find out why it functions. This leads him to study the principles of electric operation in each part of the machine and to formulate the results observed. We propose to pursue the study of business enterprise by the same method, and begin with the question: How does a business work or function as an economic enterprise? How does a steel company function, for example, not in making steel but from an economic point of view? How does any business work as a money-making enterprise?

The answers to these questions may be approached by tracing out an economic flow chart somewhat after the manner in which a chemical engineer lays out a process chart to show the steps followed in converting given raw materials into specific chemical products. The economic flow chart, instead of dealing with materials in different physical states, deals with values in different forms, such as cash, machines, materials, buildings and goods. The unit of measure of value in the United States is the dollar. From a scientific standpoint it is not an acceptable unit of measurement, because it is very unstable. A measure which one day may contain one quart and some days later two quarts would be very unreliable, to say the least. So it must be borne in mind that the flow chart of values we are about to present is based on the assumption that the unit of measurement (the dollar) does not change throughout the cycle. In Part III we will come back to this question of the dollar considered as the economic yardstick.*

A diagrammatic sketch of the economic flow chart of business enterprises as applied to manufacture is shown in Figure 1. For purposes of illustration, let us assume that a business enterprise is to be started

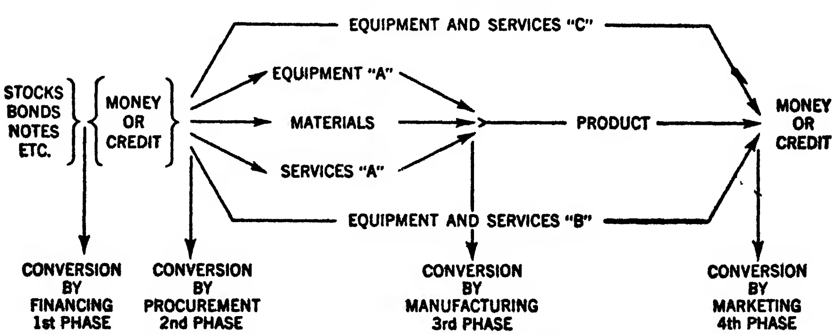

Figure 1. The Economic Flow Chart in Manufacturing

* See Chapter XIV.

with a capital of $1,000,000, to be acquired through the sale of securities. The beginning of the flow of value changes is first the creation of printed forms of contracts or agreements, termed stock certificates, and next the exchange of these for $1,000,000 cash or credit. If actual money is paid for the certificates, then the exchange is for cash. If payment is made by check, then the exchange is for credit, because the check when deposited at the bank constitutes a credit to the depositor's account. Thus the first phase consists of a flow of values expressed by the equation:

Shares of stock = Cash or credit received.

If the cash or credit received in exchange for the stock certificates amounts to $1,000,000, the shares of stock are said to have a total value of $1,000,000. We shall see later that some of the funds of business are derived from other sources, such as the sale of bonds, bank loans, and merchandise credits. *This phase of the flow may be termed conversion of values by financing.*

The next phase of the economic flow consists in the exchange of some of the cash or credit for buildings, machinery, materials, and services. If, for example, a factory is purchased for $600,000 and materials for $200,000, and the services of labor, management, power, etc., for $100,000, and $100,000 cash remains, then there has been a flow of values as represented by the equation:

$$\$1{,}000{,}000 = \left[\begin{array}{lr} \text{Factory} & \$\ 600{,}000 \\ \text{Materials} & 200{,}000 \\ \text{Services} & 100{,}000 \\ \text{Cash} & 100{,}000 \\ \hline \quad\text{Total} & \$1{,}000{,}000 \end{array}\right.$$

The values given in this equation are determined by the cash value of the payments made; for example, the factory is assigned a value of $600,000 because that sum was paid for it. We see that what was wholly liquid capital has been partly converted into fixed capital and inventory.

This phase of the flow in values, during which cash is converted into physical and other assets, may be termed the phase of *conversion by procurement.* It is obvious that all the conversions or exchanges of cash for the many items of assets do not take place at the same time, so that the term "phase" is used in a functional sense only. In the operations of a business, all phases of the economic flow chart are going on at the same time; money may be in the process of being

raised while the factory is being enlarged and new machinery may be contracted for while some of the later phases shortly to be described are being carried on. It is important to bear in mind, in forming a mental picture of the flow of values, that the several steps of conversion are arranged in a functional sequence only, without consideration of the time relationships of each unit of flow of values in each phase.

The next phase may be pictured as that in which equipment, materials, and services function together and combine to produce the product. The service of management may be looked upon as a catalyzer which causes the values inherent in machinery, raw materials, labor, and other services to flux into a combination of values embodied in a product or products. Thus this phase, which may be termed the phase of *conversion by manufacture*, may be represented by the equation:

$$\text{Values of}\begin{bmatrix}\text{factory (depreciation)}\\ \text{materials}\\ \text{services}\end{bmatrix} = \text{Value of products}$$

After this phase has been in operation for a period of time, we may find that the following flow of values has taken place:

1. Part of the value of the fixed assets, such as machinery and buildings, has flowed into the product by the process termed depreciation.
2. The raw materials are now embodied in the product, and the value of the materials is now a part of the value of the product.
3. The wages and salaries of employees are now charged to the product, as are the cost of power, insurance, taxes, and other services.

Accordingly, the balance of values accomplished by this phase of the economic flow may be:

$$\begin{bmatrix}\begin{array}{lr}\text{Factory} & \$\ \ 600{,}000\\ \text{Materials} & 200{,}000\\ \text{Services} & 100{,}000\\ \text{Cash} & 100{,}000\\ \hline \quad\text{Total} & \$1{,}000{,}000\end{array}\end{bmatrix} = \begin{bmatrix}\begin{array}{lr}\text{Factory} & \$\ \ 595{,}000\\ \text{Products} & 305{,}000\\ \text{Cash} & 100{,}000\\ \hline \quad\text{Total} & \$1{,}000{,}000\end{array}\end{bmatrix}$$

The elements of value contained in the products are:

$$\begin{bmatrix}\begin{array}{lr}\text{Factory (depreciation)} & 5{,}000\\ \text{Material} & 200{,}000\\ \text{Services} & 100{,}000\end{array}\end{bmatrix} = \text{Products, \$305,000}$$

The next and last phase of the flow in values is *conversion by marketing*, during which the product is converted into cash or receivables (open account credits, notes, trade acceptances) by the process of marketing. The marketing of the product requires the services of salesmen, of advertising, of transportation, and perhaps warehousing, and therefore the cash exchanged for these services (B) and the depreciation of equipment (B) become part of the cost of the product as delivered to the customer. The equipment and services (C) of the executive offices exercising general supervision of the entire business are also involved in the flow of values. If, then, the value of the product as completed in the factory is $305,000, and $50,000 is spent for services after it leaves the factory and is on its way to the ultimate consumer, the value of the product at the stage where it is placed in the hands of the customer is $355,000. Any sum above this amount received in the sale of the product is profit. If less than this amount is received, there is a loss. Assuming the products to have been sold for $365,000, we find that the conversion of product into money or credit results in the following set of values:

Factory	$ 595,000		Factory	$ 595,000
Product	305,000	=	Money or credit	365,000
Cash	100,000		Cash	50,000
Total	$1,000,000		Total	$1,010,000

Since the goods were sold for $365,000 and the costs of depreciation, labor, material, and service are $355,000, there remains the sum of $10,000, which is the cost to the consumer for the use of capital and is termed the profit.

It will be shown that all business enterprises have the same basic economic problems of converting "values" of one form into "values" of another form. These problems are of different relative importance in one business as compared to another, and these differences are reflected in the organization structure, in the relation of fixed assets to working capital, and in many other ways. It is apparent that the detail problems in the economics of business enterprise have their origins in the four primary phases of value changes or the conversion of values of one form to values of another form.

THE NATURE OF THE PROBLEMS ARISING IN THE ECONOMIC FLOW IN MANUFACTURING

The flow of values in business enterprise may be analyzed in somewhat the same way that the steam engineer studies the flow of energy

and the efficiencies of conversion of heat into work in the thermodynamic cycle or the electrical engineer determines the transfer of the potential energy of the electric current into the dynamic energy of the moving masses of the motor and its attached loads. In the flow of economic values, or of the energy of steam or the electric current, certain principles of operation determine the efficiencies with which each phase of the cycle will take place. In the steam and in the electric cycle, these principles of operation need to be understood thoroughly if the operation of the equipment in which they are used is to be effectively controlled. So also there is need of a thorough understanding of the factors which affect the efficient operation of each phase of the economic flow chart if business is to be managed successfully. To this end it will be necessary first to find the factors which appear at each point where flows of value are taking place and to study the nature of the operation of each factor.

The problems of the first phase of the economic flow chart are

1. The form and nature of the contracts entered into by the corporation with those who furnish the money or credit.
2. The means and the efficiency by which the contracts (written or implied) are exchanged for money or credit.

It is indicated in Figure 1 that the money or credit invested in business enterprise is obtained through the sale of securities to the public. The money thus raised becomes either the permanent capital of the business or its long-term obligations. The company gives in exchange either preferred or common stock for its permanent capital, or bonds for its long-term loans. These investments are based on contracts which give to their holders certain property rights in the assets of the business and certain rights to its earnings. One of the problems in the first phase of the economic flow chart is to obtain the funds for the business with a minimum of hazard to property rights and a minimum fixed claim on its earnings. If, for example, the funds are acquired through the sale of common stock, then there are no fixed claims on earnings and no hazards to property rights. Should the funds be raised through the sale of bonds demanding a fixed annual interest of 7 percent, then the company is obligated to pay 7 percent annually on the face of the bonds, regardless of earnings. Furthermore, if the company fails to maintain certain requirements specified in the bond, such, for example, as current assets equal to the face

value of the outstanding bonds, then the trustees, under the bond, may demand full payment of the bonds, in default of which they may seize and sell the assets of the company in order to satisfy their claims. Again, the securities, either stocks or bonds, when sold through investment bankers under an underwriting agreement, are usually bought by the bankers at a discount. For example, a bond which is bought by the public for $1,000 may be sold by the company to the bankers for $900. The company thus receives only $900 for a bond on which it may have to pay 7 percent on $1,000, and which it will have to redeem at maturity for $1,000. If a group of individuals agrees to provide the company with funds through the purchase of common stock at par direct from the company, then the company receives $100 for each $100 par value stock. This arrangement for securing funds represents a more efficient conversion of "values" through financing than the one involving the sale of bonds through bankers. The conditions under which a company may acquire its permanent capital depend on the state of the market for securities, upon the company's record, if it is an established concern seeking additional funds, and upon many other factors.

During the operation of a business, a company may obtain the use of temporary funds which it uses for a short time. Thus, when it purchases materials on credit, agreeing to pay within 30 or 60 days, it has the use of the funds equal to the value of the materials purchased for a short period of time. As it pays for materials used and buys new materials, it creates in effect a revolving fund. Thus a company's statement of accounts payable represents funds obtained through open-account credits on which it pays no interest. A company may borrow money from commercial banks or from individuals to meet temporary requirements for funds. For these funds it gives its note for 90 days, and may pay interest at the rate of 6 percent per annum.

All the sources from which a company obtains its funds are stated as liabilities in the balance sheet. Thus a company may have funds in its possession (or for which it must give account) as follows:

Accounts payable	$ 100,000
Notes payable	50,000
Bonds	500,000
Preferred stock	1,000,000
Common stock	1,000,000
Surplus	200,000
Total	$2,850,000

Of this total, \$150,000 must be returned in cash within a few weeks; \$500,000 may be payable at the rate of \$50,000 per year for 10 years or \$500,000 at the end of 15 years or on some other long-term basis; \$2,200,000 belongs to the stockholders, of which \$2,000,000 is permanent capital and \$200,000 may be used by the directors either to pay dividends or for other corporate purposes. The above amounts, of course, are not cash items but simply show from what sources the funds were received and because of which the company was able to acquire its assets.

Each of the items of "liability" represents a source of funds used in the business. The amount of the accounts payable is usually the credit supplied by those who furnish materials. Notes to individuals or banks are exchanged for money or credit. These are generally due on definite dates and bear interest. They are commonly known as short-term loans. Long-term loans are secured by bonds and mortgages and may run 5 years, 10 years, or 20 years or more. Those who buy the company's stocks, either preferred or common, supply money or credit on such terms as may be specified in the stock certificate. Such purchasers are known as the owners of the business. The surplus represents the earnings of the common stockholders which have been left in the business. The liability statement of a business shows where the company obtained the money or credit with which it acquired its assets, and indicates the nature of the agreements entered into with those who supplied the money. These agreements establish certain economic conditions of the business and fix the character of some of its financial obligations. For example, if the company raises \$1,000,000 by the sale of 7 percent bonds, it obligates itself to an annual interest charge of \$70,000 until the bonds are retired. If the same amount of money is raised through the sale of common stock, then it has none of the above obligations. It will try to earn 7 percent on the stock, but, if it does not, no risks are involved as there are with a defaulted bond interest payment.

The underwriting and sales agreements which the business enters into in securing its long-term loans (bonds) or invested funds (stocks) determine the efficiency with which it converts its obligations into money or credit. Depending on the state of the market and the availability of capital, the company may have to pay more or less commission to brokers for the underwriting or sales agreements, and these conditions may also determine the interest rate. The whole subject of the capital structure of business enterprise and the numerous

problems of finance on which many volumes are written have their origin in this phase of the economic flow chart. Our consideration of these problems will be confined to the specific effects which typical solutions of these problems have on the economic characteristics of business enterprise.

The problems of the second phase of the economic flow chart are

1. *The economic purchase of land* which means the conversion of money, or credit, into land required for manufacturing purposes, and most suitable with respect to such matters as:

    a. Transportation
    b. Building arrangement
    c. Taxes
    d. Water supply, drainage and sewerage
    e. Available sources of power and labor
    f. Available markets
    g. Available raw materials
    h. Probable future value.

2. *The economic purchase of machinery and manufacturing equipment,* so as to assure a minimum cost of production. By an economic purchase is meant the provision of low-cost manufacturing conditions at a minimum expenditure of funds.

3. *The exchange of money for those materials* which are (a) most suitable at a price for the function to be served, and (b) most suitable at a price for low-cost production of either specific parts or a group or combination of parts.

4. *The procurement of the best services at lowest cost.* Such services are:

    a. Management
    b. Technical
    c. Power, heat, and light
    d. Insurance
    e. Labor.

These two phases of the economic flow chart determine the patterns of subsequent economic performances. They establish the organic features of the enterprise and the limits or bounds of economic operations.

The third phase of the economic flow chart

This phase gives rise to the economic problems of production as far as the use of equipment, materials, and services are concerned. Under this head come all the problems of shop or factory management. Among the problems arising in this phase of the flow of values are:

a. The storage and movement of materials
b. The selection of economic lot sizes to manufacture
c. The design and use of jigs and fixtures
d. The adaptation of labor to the various jobs of production, and to services
e. The economic recording and transmission of instructions
f. Accounting and inspection
g. The selection of new and more efficient machinery and processes in keeping with engineering development.

The fourth phase of the economic flow chart

Here is involved the use of equipment such as warehouses or retail stores, and the services of salesmanship, including advertising, to convert the "value" of the product into cash or accounts receivable. The general problems involved are:

a. Creating a desire to possess among those who have the need and the means to buy.
b. Providing the system of distribution which will enable purchasers to obtain the products conveniently.

The object is to obtain maximum sales per dollar of marketing cost and maintaining good will at the same time.

It is difficult to separate these problems, because they are all intimately related to one another. The solution of any particular economic problem of business enterprise is quite similar to the treatment of the human body in health and in disease. Both surgery and therapeutics, though directed toward a specific organ, must proceed with due regard to the general relationship of the affected part to the functioning of the body as a whole. Again, just as the body must be treated in terms of its total environment, so also must a business enterprise be managed with regard to the economy as a whole. Temperature, humidity, solar radiation, water supply, sewerage, and the mineral content of the food supply establish the environmental conditions which determine the health of human beings.

The general well-being of the people in the matter of purchasing power, the tariff in relation to domestic and foreign markets, national

and international political conditions, the discovery of new materials, and the invention of new machines and processes are some of the environmental factors which must be dealt with in solving the economic problems of business enterprise as a whole.

The best solution of the economic problems of business is based on the quantitative measurements of economic forces. But often the data are not available, particularly data on the general economic environment. The methods and means for measurement are frequently based on assumptions and depend on techniques which are not always verifiable or probable in experience. As a result of these situations, the literature on the economics of industry does not always present a complete point of view on the problems with which it deals, and therefore the conclusions derived are often limited in their scope of application, and possible solutions are often empiric.

One of the most important matters to bear in mind in studying the problems of industry is that all formulated relationships which are set up to show how one economic factor is related to another are based on certain assumptions which, if not true, invalidate the whole equation. Also, both the assumptions and the data used determine the probability of calculated results being verified by experience.

THE EFFICIENCY OF THE FLOW OF VALUES

Since the efficiencies of the several phases of the economic flow chart determine the state of the enterprise, one may ask: What are some of the circumstances which affect the efficiencies of the economic flow chart, particularly its last three phases?

It is obvious that a business is started or kept in operation by the force of its purchasing power, through which it acquires buildings, machinery, and materials and hires labor and services of all kinds as needed for its many activities. Not only at the inception of the business but also during its life and growth, money or credit is being transformed daily into the equipment and services required to conduct the business. Much depends on the efficiency of conversion by procurement and, at the same time, there are no satisfactory units and means by which it may be measured.

There are no generally accepted rules by which it may be determined that the funds have been wisely spent, because the effectiveness of the investment depends in some measure on future events. Business enterprise is a venture, the success of which can be judged only by its outcome. One of the objects of this study is to develop methods of estimating the probabilities of success in business enterprise under

given economic conditions. The results attained in business as measured by profits are due to the effectiveness of equipment and management, and to adequate funds or credits, and it is impossible to determine how equipment, management, or credit each contribute separately to the final total results. It is not to be assumed, however, that there are no general principles which may be applied. This phase of the economic flow chart is the one during which some important characteristics of the business are established. For purposes of illustration, let us assume that a businessman desires to manufacture and sell a certain commodity and finds that he can invest $500,000 in the enterprise. He makes plans for a factory which he builds and equips at a cost of $450,000, leaving only $50,000 available for working capital. He then finds that in order to operate the factory at full capacity he should have at least $300,000 with which to buy materials, to pay the labor and other service costs, and to merchandise the product. Accordingly, without sufficient funds or credit to operate the factory to full capacity, the investment in buildings and machinery is largely dormant, and hence the conversion of purchasing power into fixed capital and working capital in these ratios was very inefficient.

Another businessman, deciding to enter the same industry, with an equal amount of purchasing power at his disposal, proceeds to build a plant at a cost of $300,000 and operate with a working capital of $200,000, which is the amount required for operating the plant to full capacity. The second man has converted his funds more efficiently than the first man.

A third businessman entering the same industry with a like amount of capital may, upon careful study, find that because of the small quantity required he can purchase about 50 percent of the detailed parts of the product from other manufacturers more cheaply than he can produce them himself. Accordingly, he decides to build a plant to manufacture fewer parts himself but, by purchasing the other parts, to assemble the same volume each year which the second manufacturer above referred to can produce. His plant investment becomes $200,000 with a working capital of $300,000. This may be a more efficient use of funds than the second case above cited. There are a number of ways in which this flow of values may be begun, each having a different effect on subsequent phases.

The transfer of funds, possessed or acquired through credit, into the fixed assets and working capital of the business establishes the first elements of success or failure of the enterprise. Not only does the ratio between the fixed capital to working capital condition the fu-

ture operations of the business, but the *usefulness* of the equipment, materials and services procured is also a determining factor.

A competent engineer will design and build a plant at relatively low cost and high productivity while an engineer less competent will spend perhaps 50 percent more money in building a plant of low productivity. The efficiency of conversion is high in the first instance and low in the second. Likewise, a competent designing engineer may be engaged for $10,000 a year and succeed in so designing the product, with respect to both function and cost of production, that sales are increased and costs lowered. Another engineer, who could be engaged for $5,000 a year, may not be able to design so good a product. The higher salary will represent the more efficient investment, yet the relative worth of the two investments cannot be determined quantitatively.

The purchase of materials ill-adapted for use in the production entailing high cost of fabrication, even though procured at low first cost, represents an inefficient use of funds. Likewise, the purchase of high-priced material for use in making parts for which a much cheaper material would serve the purpose as well represents an inefficient use of funds.

A management which is unprogressive, without initiative and executive force, even though engaged at low cost, represents an inefficient use of funds in providing this class of service. The funds of the business are constantly being used to purchase the tangibles and the intangibles of commerce and the materials and services necessary to the conduct of business. Every day decisions are made to buy some things or to hire somebody in anticipation of their being the best that can be secured for the money paid. In the average business many people are engaged in making these decisions, and, if the business is to be profitable, all these decisions must, by their combined and cumulative effects, contribute in the most effective manner to carrying out the objectives of the enterprise. Accordingly, there must be clearly defined objectives, specifically determined areas of responsibility, methods and means for measuring the effectiveness of attainment, and means of coordination and control. In other words, the efficiencies of the value changes depend entirely on the organization and management which directs the use of funds and credits. As civilization becomes more complex, that is, expresses itself through a greater number of social agencies and cooperative groups in all fields of human interest, and these are dependent upon and related to the economic structure, it follows that more complex types of organizations

and higher, more differentiated degrees of skill are demanded to operate business enterprises. Together with the development of the intellectual capacity necessary to operate the more complex social agencies of modern society, there must also be developed a higher sense of social obligation on the part of individuals charged with responsibilities to the group.

The purchaser of raw materials must have skill to decide which of many materials offered is best for the business, and he must also have sufficient character not to give the order to the vendor who gives him the most expensive present. The manufacturer should not be compelled to engage many unnecessary workmen in building his plant because the local labor leader operates a "racket" in labor. Demoralizing influences such as these break down the morale of organization and management, and set at naught the possible good results of skilled service. No study of economic procedure is complete unless it recognizes the parasitic influences which militate against the efficient conduct of business. *It is at this phase of the economic flow,* during which funds are exchanged for commodities and services, that the demoralizing influence of unprincipled practices is largely felt.

The efficiency of procurement requires not only that each expenditure shall result in the maximum value for the minimum outlay of funds, but also that a proper balance shall be maintained for each expenditure in relation to the funds available. The problem of relative values is ever present. It may be more economical to purchase certain materials in carload lots, for example, but, if such procedure would exhaust credit and prevent the installation of fire sprinklers with resulting reduction in insurance payments, the economy of the whole may be affected adversely.

The efficiency of operation of the third phase of the economic flow chart is conditioned in some measure by the efficiency of the preceding phase, and particularly by the ability of the management to make effective use of the machinery, materials, and services at its disposal.

The objective in operating a factory is to obtain the lowest attainable unit cost of manufacture. Most of the work in scientific management during the past twenty years has been directed toward this end. Among the classes of problems arising at this point are:

1. The effective use of materials
2. The maximum output per wage dollar
3. The maximum output per service dollar
4. The most rapid turnover of working capital.

In spite of the fact that American industry is generally believed to be efficiently operated, such notable reports to the contrary as the "Proceedings of the Industrial Waste Utilization Conferences," Purdue University, the publications of the Bureau of Standards and of engineering societies, and various technical publications, indicate that much still remains to be done.

On November 26, 1929, the Bureau of Standards issued a report with the title "Simplified Practice, What It Is and What It Offers," in which it is pointed out that American manufacturers are wasting slightly more than 50 percent of their purchasing power through lack of proper industrial practices.

Sixteen years later, Professor Robert W. Field, reporting to Purdue University Second Industrial Waste Conference (January 10, 1946), expressed himself as follows: *"There is something pathetic about the fact that, because of the increased volume of industry, waste still increases faster than we, the people, with better methods and better controls, have been able to eliminate it."*

A great amount of attention has been given to time and motion studies and methods of wage payment to labor and not enough serious study is being made in the average factory of the basic economic characteristics of the business as a whole and the formulation of policies and methods of control.

The great variety of styles and sizes of product manufactured in a single plant is often out of harmony with consumer demand and militates against economic methods in the utilization of materials and in processing. Multiplicity of detail often obscures important basic principles.

How to measure efficiency—profit and loss

The last phase of the economic flow chart is concerned with converting the products of manufacture into cash or credit of various forms. This transaction is illustrated in Figure 2.

At A is shown the cost of manufacture of the goods sold in a given period. Conversion by use has resulted in a flow of values from raw materials, wages of labor, cost of various services, and the depletion of machinery and plant through use into the finished products ready for sale. To move these products from the plant to the customer, a number of expenses are incurred. In the first place, the cost of administration of the business as a whole must be accounted for, which is not wholly a cost of marketing, since much of the expense is otherwise incurred. The expenses particularly due to getting the finished prod-

ucts into the hands of the users vary with the nature of the product and the trade practices in its marketing. The expense of the advertising necessary to create a desire on the part of the public to possess the product, the expenses of salesmen who accomplish the same result, the cost of transferring the product to convenient points of distribution so that prospective customers may easily procure the goods—these and many other expenses cause the accumulated values on the goods to stand at the mark shown in position B. If now the price received for the goods is that shown at position C, a profit of the amount shown at the top of the column C results. But this is only in

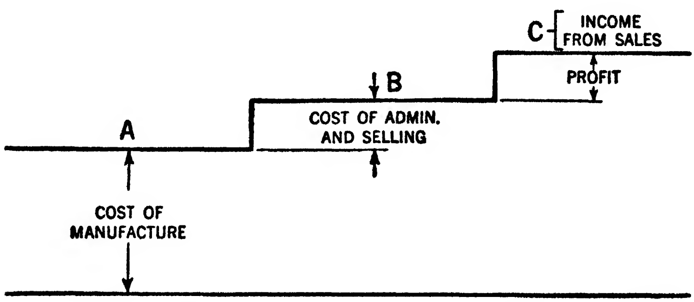

Figure 2. Steps in Costs and Profits

part a potential profit unless the goods have been sold for cash. The profit is partly potential if the total sales have been made for part cash and part credit. If some customers do not pay their accounts for one cause or another, potential profits may not be realized. Accordingly, the value of that for which the goods have been exchanged is always open to question if it is in the form of some sort of credit instrument. The efficiency of this phase of the economic flow chart depends on the competence of the management, the effectiveness of the merchandising methods employed, and the credit policies of the company.

As we view the entire flow of value changes, with particular reference to the number of these changes occurring in a business of even moderate size, we are impressed with the fact that they are very many indeed, and also that many individuals are controlling and directing these changes. The purchasing agent exchanges the company's funds or draws on its credit for thousands of articles each year. The shop superintendent directs the service of labor to innumerable tasks each day and thereby controls the exchange of the wage dollar for inventory. The general manager directs the exchange of the company's funds for new productive machinery, the maintenance and operation

of which, together with its depreciation, appear in the cost of the inventory. Every officer, executive, and department head is directing in some measure the forces which determine the efficiency of the flow of values. Is it conceivable that the highest efficiency is attainable if each unit in the organization works independently of the others, or without a commonly agreed-upon plan of procedure?

The margin between success and failure in business is very narrow. Slight errors in judgment in each of the many instances of value change can easily, by their cumulative effect, wipe out what would otherwise be a desirable margin of profit. *Administration,* therefore, by which the design of all details of operation is established, *management* through which the provisions of the design are carried out, and *control* are services of the highest importance. The policies of operation of a business should be based on the economic characteristics of the particular business to be operated. The design of the organization must accord with these policies. Management should carry out the policies of the directors of the business through the medium of the organization which is established. Control should be provided to assure compliance with standards.

Business enterprises differ one from another in the relative influence of different factors in the economic flow chart. In some industries the processes of manufacture, particularly the machinery of manufacture, are controlling factors, while the service of labor is relatively less important. This is the situation in the production of cement, granulated sugar, and flour, to mention a few. In the manufacture of locomotives, ships, and steel dies for forging and drawing operations, the labor factor assumes a greater importance. In the manufacture of scientific instruments the procurement of materials is less important than in the meat-packing industry, but the labor factor is just the reverse.

Conversion by marketing is a relatively small factor in the newspaper business as compared to the automobile business. Qualitatively, all industries follow the general economic pattern described above; quantitatively, however, the incidence of certain factors in the flow of values is such that the widest differences in policies of operation are required. It is important to visualize the general relationships in the economic flow chart in order to acquire a proper perspective of the whole before the policies through which these relationships are brought under control are established. With such visualization a business may be operated through the application of *principles.* Without such visualization a business is necessarily run by *rules.* Rules are

means for maintaining a state of things. Principles are dynamic means for adapting procedure to changing conditions. Since business is always in a state of flux, it is imperative to success that there shall be guiding principles of procedure, and these principles can be discerned only when there is a full and complete understanding of the whole sequence of value changes and of the relationships of the factors which are influencing these changes.

THE ECONOMIC FLOW CHARTS OF OTHER TYPES OF BUSINESS

The kinds of economic problems which are found in the manufacturing industries are typical of those to be found in all types of business. The following brief statement of the nature of the economic problems peculiar to other business enterprises may serve to give a more complete perspective of the economic problems of business enterprises as a whole.

There are, in general, seven major divisions into which business may be classified. They are:

1. Manufacturing (*discussed above*)
2. Agriculture
3. Mining
4. Building and construction
5. Transportation
6. Utilities, such as power, gas and communications
7. Trade.

2. *Agriculture.* The business of agriculture consists in the use of land, equipment, materials, and services for the planting, cultivating, harvesting, and marketing of crops.

The land is an asset of value in proportion to the available plant food contained in its top soil. The plant foods are taken from the soil by the growing plants and become part of the material which the farmer sells when he markets his crops. In selling his crops the farmer is selling part of his land, just as the manufacturer sells part of his factory when he disposes of the products he makes. The farmer also sells part of the fertilizer he puts on the land, as well as part of the machinery and buildings used on the farm. He also sells his services and those of his employees.

Accordingly, as shown in Figure 3, there is a flow of values from land, equipment, materials, and services into crops, and the "book" value of the crops is derived from these four sources.

The problems of agricultural economics differ from those of manufacturers in several important particulars. The land used by the farmer is not valued in terms of the plant food it contains. The early settlers in the rich Mississippi plains, for example, were given their land by the government. Much of this land had about 9 inches of top soil, rich in plant food. At the present time, this same land, having from 4 to 5 inches of top soil, sells for $100 to $200 per acre. The price at which land sells seems to depend largely on factors other than fertility.

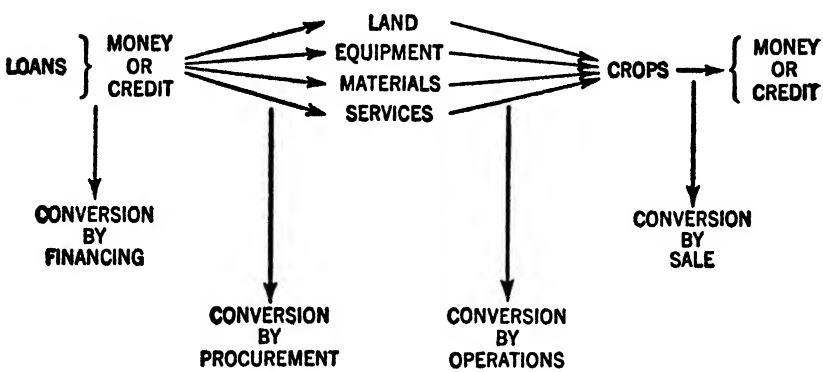

Figure 3. The Economic Flow Chart in Agriculture

When a farmer buys land, machinery, and supplies he cannot sell securities guaranteed by the assets or earnings of his business, as the manufacturer frequently can. He generally borrows money at the bank and gives a mortgage on his land and a chattel mortgage on his machinery and livestock. These mortgages are often purchased by life insurance companies. About five billions of dollars worth of such mortgages were outstanding in 1947. Very few farmers keep books of account and therefore have no reliable estimates of the costs incurred in raising and marketing their crops. Nevertheless, it is a fact that the success of the business of agriculture is determined in part by the efficiency with which money or credit is obtained and used in the purchase of land, equipment, materials and services; and the effective use of these in operations. But the prices at which crops may be sold are totally beyond the farmer's control, which is not the case with the manufacturer. The price of wheat is largely determined on the Liverpool Commodity Exchange and the Chicago wheat pit, and the prices of cotton, corn, hogs—in fact, of everything the farmer sells—are fixed

by agencies beyond his control. Furthermore, when he plants a given acreage in the spring he is committed to a volume of production which he must proceed with, no matter how the market for his products may vary. In this respect he is not so well off as the manufacturer, who can alter his rate of production during the year, in accordance with prices and demand. It is interesting to note that, even though the farmers' problems are set in entirely different circumstances from other businesses and require wholly different procedures for their solution, the economic flow chart for agriculture follows the same general pattern as that of the manufacturing industries and, as we shall see shortly, of other types of business.

3. *Mining.* Those engaged in the business of mining are procuring and selling the natural resources of the earth, from land which they either own or lease for mining purposes.

The land containing coal, oil, gas, copper, zinc, or iron ore, to mention a few important minerals; the machinery, and structures for operating the property; the materials consumed in operations; and the services of miners, accountants, and managers—all are factors entering into the book value of the minerals and ores which the mining company sells. Mining companies may be financed by the sale of securities, and, just as in other businesses financed in these same ways, the prices paid and obligations incurred for money and credit, as expressed in the terms of the securities sold, are important in the efficient conduct of the business.

As seen in Figure 4, the basic pattern of the economic flow in the mining business is the same as for manufacturing and agriculture. The problems of converting "value" in one form to "value" in another

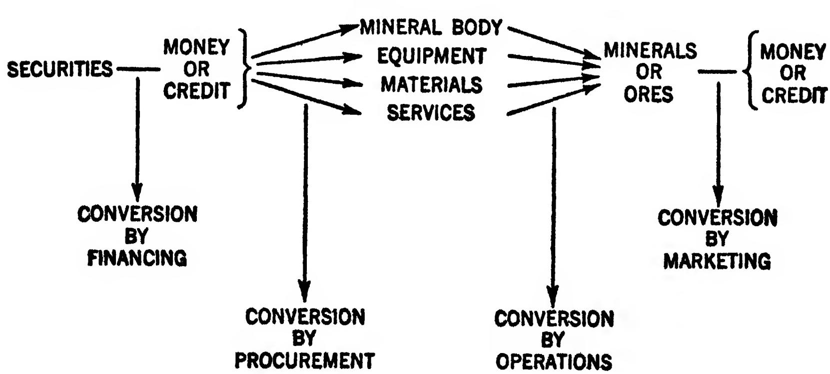

Figure 4. The Economic Flow Chart in Mining

form lie in the four primary phases of the flow. In accounting for the flow of values during the phase of operations, the procedure with respect to services, materials used, and depreciation of machinery and structures follows the general practice found in the manufacturing industries. The mineral body or deposit, however, is accounted for on the basis of its depletion, or the rate at which it is being exhausted.

4. *Building and Construction.* Those who engage in the building of houses, stores, factories, hotels, and other structures, and in the construction of tunnels, docks, piers, wharves, bridges, and works of similar character, are creating a single product and selling it as a whole, or gradually, together with services, depending on the following circumstances.

If the business of the company is designing and building structures

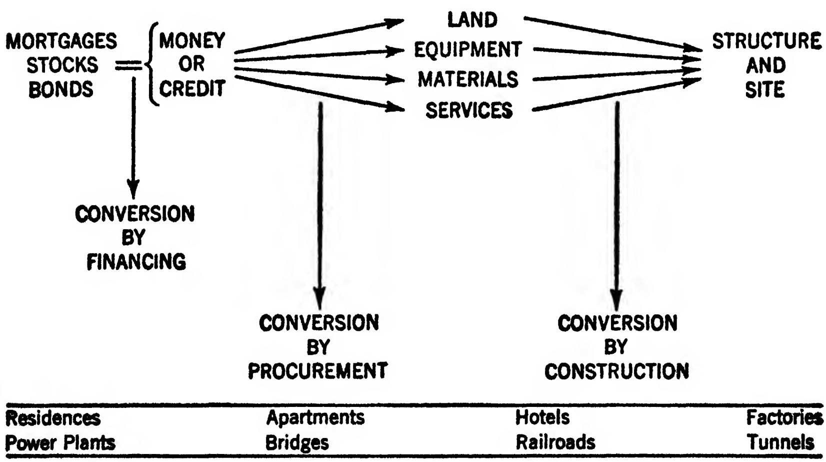

Figure 5. The Economic Flow Chart in Building and Construction

for others, then the product (structure) is sold as a whole to another company which operates it. In this event, the economic flow chart governing the business is as shown in Figure 5.

If a ferry company, for example, builds a ferry slip (or a railroad corporation constructs a bridge), it intends to sell these structures to its passengers over a period of years, by including the depreciation of the structure in the cost of the services which it sells. In that event, the economic flow appears as shown in Figure 6.

Engineering construction companies frequently find that the securing of a contract to build a power project, or other works of that

character, depends on the assistance they can render in obtaining financial underwriting for the project. Thus, many such firms either associate themselves with investment bankers, or operate subsidiary companies, organized for the purpose of financing such projects. Sometimes companies building apartment houses on speculation will invest their own funds in a plot of ground and finance the building through funds obtained by mortgage on the whole property. The property may be sold to others upon its completion, subject to the mortgage, or it may be transferred to an operating company, which rents the building and manages the property. Thus, the first phase of the economic cycle, the conversion of securities into money or credit, for businesses engaged in building operations, may take many forms, and the efficiency with which this phase of the flow is operated constitutes an important problem in this business.

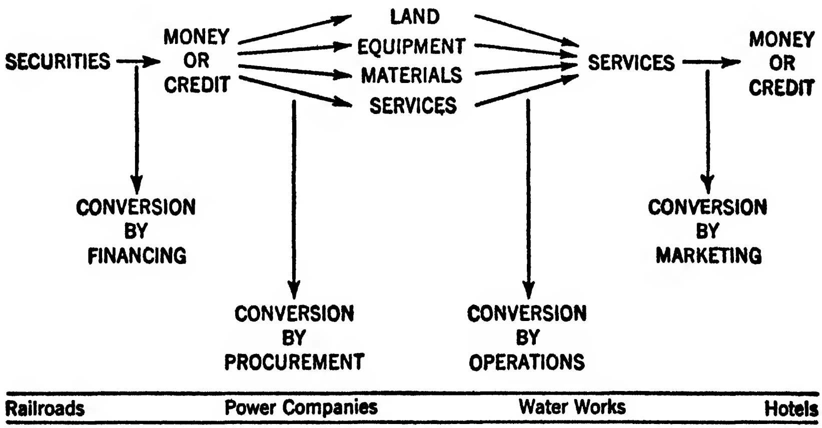

Figure 6. The Economic Flow Chart in the Transportation Industries and Other Public Utilities

The second phase of the flow, conversion by procurement, consists in the procurement of the four primary elements of operations: land, equipment, materials, and services. The purchase of the land or site often includes the cost of tearing down an existing structure, and of other operations necessary to the clearing of the site. The equipment procured may be purchased for use in building the structure and then discarded if worn out on the job, or it may be rented, or it may be used in a number of building operations. In any event, the cost of equipment consumed or partly consumed becomes part of the cost of the completed structure. The value of the materials of construction,

as well as the costs of labor, and all other services such as engineering and supervision, flow into the value of the building through the process of conversion by operations.

The next phase of the economic flow, during which the "value" of the land and structure is converted into money and credit, is generally provided for before building operations are begun. In speculative building, the sale of the property may take place after construction and occupancy.

In any event it is interesting to note that the pattern of the economic flow in the business of building and construction is of the same general type as those previously considered.

5. Transportation, and *6. Other Public Utilities.* The business of transportation of passengers and materials, whether by rail, automobile, water, or air, we find, follows the same general pattern of economic flow. This kind of business is financed by the sale of securities and therefore has the first phase of conversion of written obligations for money or credit. The money or credit is converted into the elements of land, equipment, materials, and services, in which phase will be found the same general types of problems as in other business enterprises. In the conversion of values through operations, the values of the four primary elements mentioned above flow into the value of services created, and the efficiency of this phase determines the level of cost. In the next phase of the economic flow in which the company seeks to sell its services above the cost of their creation, the selling price of the service is regulated by the Interstate Commerce Commission. This regulation exists to protect the traveling public and shippers against exorbitant charges for service which may come about because the company has a monopoly in much of the territory in which the service is rendered. Competition, however, does exist, as, for instance, between adjacent railroads, the railroad and air lines, and railroads and bus routes; therefore, the business of transportation does involve some of the problems of merchandising common to other businesses. Government regulation introduces several problems in cost determination which are not found in manufacturing and some other businesses. Since one of the items of cost of service is the charge for depreciation of physical assets, it becomes necessary to adopt some rational basis for determining depreciation in establishing equitable rates and charges for transportation. All public utilities subject to government regulation as to rates to be charged for services must have their accounting practices approved by the regulating body, particu-

larly the methods for valuation of the assets to be depreciated and the amount of depreciation to be written off each year. Therefore, such businesses must maintain staffs of accountants, attorneys, and engineering experts to deal with problems of legislation and the hearings and rulings of regulatory commissions. These kinds of business activities, however, do not alter the general pattern of the economic flow, as an examination of Figure 6 will show.

7. *Trade.* The business of wholesale and retail trade, though wholly different in many features of operation from those of manufacturing and public utilities, for example, nevertheless conform in general patterns of value changes to the basic pattern of the economic flow chart.

The larger businesses, such as Sears, Roebuck and Company and the United Cigar Stores, to mention only two of national importance, obtained their original funds through the sale of securities. Small retail stores are generally financed by private capital, and many are owned outright by a single proprietor. Invariably, however, their funds are used for the procurement of the four elements with which business enterprises are conducted. Land and equipment are either purchased outright, or, as is true of small stores, the use of these assets is acquired through rental, and only the equipment such as counters, shelves, cash registers, and delivery trucks are purchased. Materials are purchased for resale and, of course, constitute the important item of assets.

Funds are invested in the services of clerks, managers, and accountants, as well as in insurance and taxes.

The values of these four primary elements flow into the value of

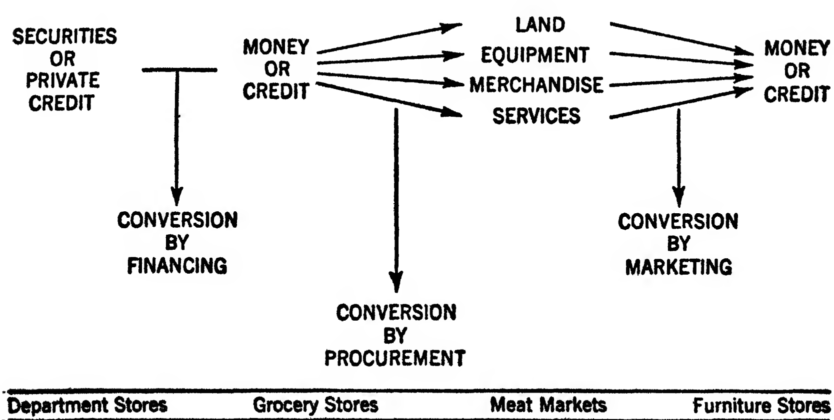

Figure 7. The Economic Flow Chart in Trade

the merchandise as delivered to the customer, and thus the control of this flow of values through merchandising is also an important phase of this business. The phase in which values are converted by operating disappears or is merged with that of merchandising. Thus the basic pattern of the economic flow in the businesses of wholesale and retail trade is as shown in Figure 7.

In summary, then, it appears that all types of business enterprise follow the same general pattern of the flow of values, consisting of the four general phases of conversion: first, by financing; second, by procurement; third, by operations; fourth, by marketing. The subject matter of the economics of business enterprise is derived from what occurs in these four phases of the economic flow chart. Since this book is written primarily for students of engineering, the main emphasis in its treatment will be on those activities with which the engineer is more closely identified, namely procurement and operations; and the problems of financing and marketing will receive only so much consideration as may be necessary to illustrate their general relation to the problems of procurement and operations.

II

FINANCIAL STATEMENTS

THE ECONOMIC FLOW CHART shows the general sequence in the flow of values in business enterprise. It indicates *qualitatively* the nature of the economic processes involved in the operation of a business. As such, it furnishes background and perspective for the comprehension of the *quantitative* problems of the economic processes of business, which we are now about to inquire into. The efficiencies of conversion of values in the areas of finance, procurement, manufacturing, and marketing impose problems of quantitative measurement. To this end it must be known what are the values in these areas at any given time and what changes in value have occurred during a given period of time. The values at any given time are recorded in the Balance Sheet. The change in *total value* during a given time period is recorded in the Profit and Loss statement for the given period under review. Neither of these financial statements are entirely sufficient in themselves for the determination of efficiencies in *financing* the business, *procuring* its machinery,

building materials and supplies, and in *manufacturing* and *marketing* the products. To these ends we need to make further studies.

One of the main reasons why financial statements such as the balance sheets and the profit and loss statements should be amplified and their data developed by some other kind of study lies in their very nature and the purpose for which they were originally designed.

The almost exclusive original purpose of the balance sheet and profit and loss statement was, and their main purpose is still, auditing. To serve this purpose they must reflect directly or indirectly any transaction with the greatest possible accuracy. They must go into very minute details. They are analytical, by nature. Also, they are mainly, if not exclusively, concerned with actual data—not with any comparison with a given standard to which the actual performance could be compared. There is a need, therefore, for other techniques that will enable management to appreciate the value of the performance by comparison with given standards. There is also a need for a more synthetical presentation, giving management an easily understood, general picture of the business, which is given in Chapter IV, *et seq.*

The present chapter deals with the nature and meaning of the information contained in the balance sheet and profit and loss statement.

Before entering into such a discussion, it might be helpful to the reader who is not yet familiar with the elementary concepts of accounting, to give a brief explanation of the difference between the two fundamental financial statements: the balance sheet and the profit and loss statement. The difference can be best explained by a comparison with the difference between photographs and movies.

The balance sheet is a representation of the economic flow at a certain time—a picture of it. The profit and loss statement is a description of what has actually happened during a certain period of time as a result of the flow of values, just as a movie could be.

The first is a static document while the second is a dynamic one, both being quantitative analyses, in function of time, of the economic flow of the business.

A. THE BALANCE SHEET

1. General Principles. A tabular statement of what a company owns, the form in which the property exists (materials, land, machinery, etc.), and an estimate of the value of each, together with what it owes and the nature of the obligations, is termed a balance sheet. That which is owned is an asset, and that which is owed is a liability. The

balance sheet is therefore a statement of the assets and liabilities of a company as a legal entity.

The financial operations of a business are accounted for by the process of keeping books. The "books of account" are used to record all "transactions" and "exchanges" of commodities and services, such as material and labor, for money or credit. These books then serve as indicators of the flow of values in the conduct of a business. The great multitude of such transactions which take place in the course of business are kept in various books of account from which they are summarized periodically in the balance sheet. The balance sheet may also be viewed as a record of the state of a business at a given date, in terms of what the company possesses or owns (assets) and who provided the money or granted the credit (company's liabilities) with which it acquired its possessions. Thus in simple form a balance sheet statement may read as in Table I.

TABLE I

A BALANCE SHEET

We Own (Assets)	
1. Money (cash)	$ 10,000.00
2. Promises to pay us (accounts receivable)	20,000.00
3. Materials (inventory)	30,000.00
4. Land	40,000.00
5. Buildings	100,000.00
6. Machinery	100,000.00
TOTAL	$300,000.00

We owe (Liabilities)	
1. Merchants who sold us materials	$ 20,000.00
2. Bankers who loaned us credit for 90 days	5,000.00
3. Many people who loaned us on long-term credit and to whom we gave bonds	125,000.00
4. Many people who loaned us credit for the life of the business and to whom we gave stock certificates	100,000.00
5. By charging people who bought our goods more than it cost us to produce the goods, we have accumulated	50,000.00
TOTAL	$300,000.00

Thus there is had "an accounting" of the business in terms of how much money and credit is in the possession of the business at a certain date and what kinds of credit instruments were exchanged for the credit extended, together with a record of the use to which this

money and credit were put as evidenced by the kind and value of the property possessed, all expressed in terms of a common unit, the dollar. The statement is termed a balance sheet because the assets and liabilities are balanced. This equilibrium between assets and liabilities is an obvious consequence of the fact that the economic flow of a business proceeds by conversions (see preceding chapter).

The statement of the forms of property possessed, particularly their "values" in terms of the dollar unit, are for the *date* of the statement only. They will be different the next day, and on all days following, because a flux in values is taking place constantly. The nature of this flux in values is as follows: Cash flows into materials, labor, and services; these combine into inventory; inventory flows into accounts receivable; receivables flow into cash. Machinery and buildings flow into inventory by the process of depreciation as a factor in factory expense; inventory flows into accounts receivable; accounts receivable flow into cash. This process was the subject of the preceding chapter.

The same sort of flow occurs with the liabilities and between the liabilities and the assets. Accordingly, it is important in the operation of business enterprise to maintain and regulate this flux in values to conform to the amounts and times of maturity of obligations. The values stated in the balance sheet are "book values" derived by the process of accounting for the use of funds, that is by the process of auditing. They also, as in the case of contingent liabilities, show an estimate of the probable future flow of funds into certain categories of expense and, as in the case of inventory, may show values on the basis of the market prices or materials if and when these are less than the prices paid in acquiring them.

2. Classification of Assets. The assets of the balance sheet are grouped in certain categories, as illustrated in the simplified example in Table II.

It will be noted that the assets are listed according to three general classifications, namely: *current assets,* which are assets in the form of cash or items which are readily convertible into cash; *fixed assets,* which are the permanent investments of the business; and *other assets,* which are generally items paid in advance. If these items had not been paid in advance, cash in the above example would be $25,000 greater.

There is no standard form of balance sheet in general use, but the items of current assets and fixed assets will usually be found in every balance sheet.

TABLE II

BALANCE SHEET

A. B. Manufacturing Company

New York City
December 31,19–

ASSETS		LIABILITIES	
Current		*Current*	
Cash	$ 100,000	Accounts payable	$ 50,000
Accounts receivable	250,000	Notes payable	190,000
Inventory	650,000	Accrued items	10,000
Total currents assets	1,000,000	Total current liabilities	250,000
Fixed		*Other*	
Plant	2,500,000	Mortgage	750,000
Branch office equipment	150,000		
Automobiles	250,000	*Reserves*	
Investments	600,000	Contingencies	50,000
Total fixed assets	3,500,000		
Other		*Capital and Surplus*	
Unexpired insurance	10,000	Capital stock preferred	1,500,000
Prepaid taxes	15,000	Capital stock common	750,000
		Surplus	1,225,000
Total other assets	25,000		
TOTAL ASSETS	$4,525,000	TOTAL LIABILITIES	$4,525,000

One of the principal duties of the management, as far as the supervision of financial operations is concerned, is to see that the fixed assets of the business, as represented by machinery and plant equipment, are sufficient to produce and handle the requirements of the sales department, and to provide adequate current assets to purchase materials, meet the payroll each week, maintain sufficient inventory, accommodate customers by carrying their accounts for 30 days or more, and discount their bills promptly. The assets of the business may be likened to the defensive and offensive forces of a nation. If a country had all its military equipment in the form of fortifications (fixed assets) it would have no mobile equipment (current assets) with which to carry on its military operations. If all of the capital of a business is invested in plant and machinery, there are no means for providing material, labor, and services to run the plant.

The amount of current assets required for a given business, as well as the investment demanded in the way of fixed assets, will depend entirely on the nature of the business and the volume of sales. There

is a desirable value or a limit for each item of the balance sheet for every business, and any departure from these limits will constitute some hazard to the business. Cash should not run below a given amount. Accounts receivable should not run above a certain limit. Inventory should not be *more* than a stated sum or *lower* than a fixed amount. Investment in plant should not be larger than required for sales demands.

Every manager should know these limits for his particular business and direct its affairs so that each item of the balance sheet reflects a healthy situation and does not become a source of hazard.

There are three principal divisions of the current assets:

a. *Cash,* which is composed of deposits in the bank, money in the hands of agents, petty cash in the office, and money located at other authorized places. A carefully supervised budget of income and expenditures, which provides for the maintenance of a good cash reserve, is a very important factor in business.

b. *Accounts receivable,* to be perfectly frank, represent the amount by which the manufacturer is acting as a banker to his customers. Carrying customers on open account may result in quite a hazard, and therefore this item should be very carefully managed.

Accounts receivable representing over 30 days' business indicate a too liberal credit policy. If, for example, a company does a business of $1,000,000 per month, and its accounts receivable are $2,000,000, it indicates that some customers have not paid their bills for 2 months or more and are likely to become delinquent.

c. *Inventory* represents the money value of direct labor, raw material, and factory expense accumulated in finished goods and goods in process. Inventory is frequently given as valued at "actual cost,"* or the market value, whichever is lower. What this means is that in an appraisal of assets the drop in the market price of raw materials, if any has occurred since the material was purchased, has been taken into account. In judging the value of assets, considerable attention should be given to the inventory items. Very frequently the values given are deceiving. Suppose, for example, that an inventory has been accumulated with the factory running at 25 percent of normal capacity, and resulting in a factory expense of 250 percent on labor, while, with 100 percent factory operations, the factory expense may be only 100

* "Actual cost" may be determined by various methods such as *LIFO, FIFO,* etc. See *Practical Controllership,* Chapter XVIII, *et seq.,* by David R. Anderson, Chicago, 1947.

percent on labor. An inventory value based on 250 percent factory expense would not be fair. The writers recall a very troublesome appraisal in which the above situation was encountered. The management of the inventory item in the operation of any business must be conducted with special care, for reasons which will be referred to subsequently (see Chapter III).

It is frequently found that, owing to changes in manufacture, or for other reasons, material which once had value is no longer valuable because it cannot be disposed of. Accordingly, the inventory should be divided into three general groups:

(1) Current
(2) Slow-moving
(3) Obsolete.

Current inventory (1) is that which is applicable to current sales and may be disposed of at a profit within a reasonable time. *Slow-moving inventory* (2) is that which applies to orders which are received only occasionally or to repair parts for which there is an occasional call. It cannot be disposed of in the near future and may also have to be disposed of at prices much lower than inventory values. Such inventory items are written down in value by a conservative management. *Obsolete inventory* (3) is that which applies to goods for which there is no demand and which, as such, have only scrap value. If such inventory has not been written down but is carried on the books of the company at acquired cost, the inventory is inflated.

From the above statements it is evident that estimates of inventory values may vary widely and are often subject to question.

d. *Fixed assets* is sufficiently clear in meaning. Attention is called, however, to two different ways of reporting this item. It is sometimes the practice to report the original purchase price or the appraised value of the plant and equipment without deducting for depreciation each year, but carrying a depreciation reserve on the liability side of the account. Others deduct the depreciation each year and report the net value as assets. Care should be exercised in reading this item to note whether adequate depreciation has been allowed.

e. *Other assets* refers in general to those items of assets which cannot be classed as current because they will not be soon converted into cash; or fixed, because they are not a part of the operating equipment. Among such items may be prepaid items, such as insurance; invest-

ments in subsidiaries; investments in other properties, such as housing for employees not used directly in the business; and other items of the same nature.

3. *Classification of Liabilities.* The *liabilities* are the obligations of the corporation. They also disclose the sources of funds through which it has been possible to acquire the assets. These funds are furnished by two general groups—the creditors and the owners. Among the creditors there are two general classes: short-term and long-term. The obligations to short-term creditors are known as the current liabilities; those to long-term creditors are variously listed in terms of the documents of indebtedness they hold.

a. *Current liabilities* are those incurred through materials purchased on open accounts, bank loans on short-term notes, and services and supplies furnished on credit. It is generally assumed that current account items will be paid within 30 to 60 days. The current liabilities may also contain *accrued items* which are payable at stated periods and have accrued to date to the amount stated in the balance sheet. Such items may relate to insurance and taxes. Again, if wages are paid on a Friday and the balance sheet happens to be drawn up on a Wednesday, the wages accrued in the interim also appear under the heading of accrued items.

b. *Other liabilities* are those on which payment is due at a distant date. If, for example, money has been received on mortgage, the mortgage may be payable in 3 years or 5 years. To facilitate the raising of funds from a large group of people, a company may issue notes of $1,000 or other denominations, which notes are secured by a mortgage. For example, a company may sell 1,000 notes of $1,000 each, the total amount of which may be secured by a mortgage on property worth $2,500,000. The interest payable on these notes is usually due semiannually. Assume that they are due January 1 and July 1. Thus, on March 1, there should appear among the accrued items an amount of $10,000 on account of 2 months' interest on $1,000,000 at 6 percent accrued. On May 1, this will amount to $20,000 and should be transferred from accrued items to current liabilities because it is due and payable within 60 days of that date. These same remarks apply also to partial payments, if any, required to reduce the mortgage on specified dates. Accounting for such liabilities may, however, be made through setting up reserve accounts, but it is believed to be better practice, that is, the authors believe it to be better, to account for such payments due as above set forth.

c. *Reserves* are items set upon the balance sheet to account for payments which may have to be made at some future date on account of certain obligations contingent on the business. Reserves represent withdrawals from surplus. For example, if a suit should be brought against a company on account of alleged patent infringement, the defense of this action requires funds. The directors may estimate that it will cost $50,000 to settle this matter (their estimate may be wrong), and they will direct that a reserve, on account of this suit, of $50,000 be set up. Setting up this reserve is a way of stating that some day the company may have to pay out at least $50,000 because of this suit.

If dividends on preferred stock are accrued but not payable for some months, a reserve on account of dividends accrued may be set up. A reserve for depreciation may also appear in this list. Since a reserve account indicates the probability of payment of cash at some future date, it is obvious that the treasurer of the company must control his cash resources with some regard to the possibility of such payments. There should, therefore, be some rational relation between the amount of reserves and cash on hand. Sometimes cash to the total amount of the reserves may be withdrawn from the general funds and put into a separate bank account. If the company is not in funds and the payment anticipated as expressed in the reserve eventuates, the company may be embarrassed if it cannot negotiate a loan to meet the payment when due. A reserve does not mean much unless represented in cash, for a simple withdrawal of an amount from surplus (on paper) and transfer to a reserve account does not provide the cash.

d. *Capital stock* is a liability of the company to certain individuals who have advanced funds to be used at the risk of the business. The evidences of such indebtedness are the stock certificates. These certificates in general state that the ones to whom they are issued have certain specified rights with respect to earnings or payments of cash upon liquidation of the business or otherwise. Not all stock certificates are issued for cash, nor are all certificates of a definite par value. In general, there are two classes of stockholders: Those who hold preferred and those who hold common stock.

Preferred stock is so termed because it is preferred as to earnings and may be so as to assets. Not all preferred stock certificates are alike, any more than all contracts are alike. Preferred stock is an agreement between the company and the holder, and its value depends on what has been agreed upon and the ability of the company

to meet the terms of the agreement. Among the terms which may be agreed on are:

(1) The preferred stock shall have the first lien on earnings before the common stock.

(2) The earnings are fixed and payable at stated periods. Thus a preferred stock may bear dividends at seven percent of its face value, payable annually.

(3) It may be cumulative, and therefore the dividends specified are obligations, even though they may be deferred.

(4) It may have no voting rights unless the dividends are not paid for a certain period of time after they are due. If the bylaws of the company provide that there shall be a board of directors of nine members, the preferred stockholders may elect the total of nine or only five or maybe three, as the case may be, if the dividends on the preferred stock are passed. Sometimes this right is not provided for.

(5) It has certain prior rights over the common stock upon liquidation or sale of the business. If, for example, a business is sold for $800,000 and the preferred stock outstanding is of the par value of $1,000,000, then the holders of preferred stock may be paid 80 cents on the dollar and the holders of common stock get nothing.

Common stock of a company in addition to title of ownership is in general a right to earnings when, as, and if declared as dividends by the directors. Common stock certificates may have a par value or may be of no par value. When a company sells no-par-value stock, the price at which it is sold by the company is determined by the board of directors under regulations fixed by the bylaws of the state granting the company's charter. Thus a no-par-value stock may be sold for $10 or $5 per share, or for other amounts. It may also be issued for services or other valuable considerations. It may pay dividends of $10 per share or $100 per share or any other amount, according to the earnings of the business and what the directors may specify to be paid. In declaring dividends, the directors are limited by certain statutory laws and should be guided by good business judgment. Dividends are payable out of surplus. If a company has a surplus of $500,000, even though the earnings for the past year were nothing, the directors *may* declare a dividend of $100,000 or $200,000 or other amounts on the common stock, or they may declare no dividend if they feel that the money is needed in the business. If a company has

a deficit of, say, $500,000, no dividend can be declared, even though the earnings for the past year may have been $1,000,000.*

Sometimes two classes of common stock will be encountered—a Class A and a Class B. It may be provided that Class A has all the voting rights and Class B none. It may also be provided that Class B shall have a dividend of a certain amount before Class A can participate in the earnings. The purpose of this provision is to centralize the voting control within a small group of stockholders, usually the originators of the enterprise.

The money value of the common stock stated in the balance sheet should be just what was paid to the company upon its issuance. If, for example, a company had issued at one time 500 shares of no-par-value common stock for $10 a share and at another time had sold 1,000 shares at $12 per share, the balance sheet should show an item of

$$\text{Common stock} = \$17{,}000$$

e. *Surplus* is that amount which is owing the stockholders in addition to that which is owed them on account of the book value of their stock certificates. Surplus does not represent cash, but is simply an account of indebtedness of the company to its stockholders. If, however, the directors encounter a situation for which they believe a reserve should be set up and the reserve is set up by proper authorization, then the indebtedness of the company to its stockholders is thereby automatically reduced by the amount of the reserve because the procedure in such cases is a transfer from surplus to a reserve. If the conditions because of which the reserves were set up disappear, and no expenditures were made from the reserve, it may be transferred back to surplus.† Earned surplus (from which dividends may be declared) is derived from the earnings of the business. Capital surplus is derived from the sale of stock at a premium, and from a write-up of assets.

4. *Value of Assets and Liabilities.* The values of the asset items and the liability items of the balance sheet are based on either money transactions or on estimates. For example, when a machine tool is purchased for $5,000, its value in the books of account is recorded as $5,000. If a duplicate of the above machine (new) should be purchased a few months later at a bankruptcy sale, for $3,000, its value

* The deficit at the end of the preceding year would have been $1,500,000.

† The distinction between *reserve* and *surplus* is therefore very definite. In practice, however, some confusion may arise due to an unjustified but extensive use of the word "reserve." (See page 51 concerning the *net worth* of the business.)

would be recorded as $3,000. Some accountants may add the freight charges and placement costs to the "value" of the machine as an asset, while others may absorb the freight and placement costs in current expenses. The value of the inventory of goods manufactured at the plant contains a charge for depreciation of the assets used in their manufacture. This charge is based on an estimate of the useful life of the assets used. If the estimate of the useful life is 5 years, the depreciation charge is twice as great as if the useful life of the assets used is estimated to be 10 years. If a given raw material is purchased at 20¢ a pound, the raw materials inventory will reflect this fact. But if, at the end of the year, there should be 10,000 pounds of this material on hand and the current market price is 15¢ the pound, then the auditors of the company's books will "write off" $500 from the inventory to reflect current market price. However, if at the end of the year the current market price of above material is 25¢ a pound, this increase of 5¢ a pound would *not* be added to the value of the inventory.

Liabilities are expressed in dollars and cents in an attempt to state the amount of money which may have to be spent or paid out in meeting certain obligations when they become due. Certain liabilities can be very definitely expressed; others cannot. For example, a threatening patent suit establishes a contingent liability because of the expenses for defending it. No one can tell what these expenses may be. Reserves may be set up in the balance sheet as an expression of the probable amount of money which may have to be paid out if certain contingencies occur. Perhaps, when lawsuits are pending, no reserve has been set up. Does the balance sheet show all values of liabilities?

B. THE PROFIT AND LOSS STATEMENT

Definitions. A financial statement of the results of conducting a business for a given period of time (usually a month or a year) is termed the profit and loss statement. A simple form of such statement is given in Table III.

The items of the profit and loss statement are to be interpreted as follows:

Sales means actual billings to customers for goods shipped during the month. Sales are not orders, that is, an order does not become a sale until goods are shipped and billed to the customer. Thus a company may have received $1,256,520.16 of orders during the month, but if it has only shipped $971,250.16 during the month, the sales are the latter amount.

TABLE III

PROFIT AND LOSS STATEMENT

A. B. Manufacturing Company
For the Month of January, 19–

Sales		$857,393.22	
Discounts and allowances		1,116.40	
Net sales		856,276.82	100 %
Cost of sales			
Labor	$242,986.10		
Material	157,321.16		
Factory expense	209,110.09	609,417.35	71.1%
Gross profit		246,859.47	28.9%
Administrative expense	24,732.07		
Selling expense	76,117.22	100,849.29	11.7%
Operating profit		146,010.18	17.2%
Other income		216.14	
		146,226.32	
Other expenditures		1,513.20	
Net profit		$144,713.12	16.9%

Allowances are deductions from billed price to customers on account of returns of goods for any reason. *Discounts* from billed prices may be allowed for prompt payment or other reasons.

Net sales then represents the actual sum of money which has been or may be expected to be received for goods sold.

Cost of sales is a term current in accounting practice and means the cost of manufacture of the goods sold.

Labor means the direct labor cost of the goods.

Material means the direct material cost of the goods.

Factory expense means that portion of the cost of possessing and operating the factory which is properly chargeable to the goods sold.

Factory cost is the sum of labor, material and factory expense.

Gross profit is the difference between net sales and factory cost and is the profit realized before administrative and sales expenses have been deducted.

Administrative expense and *selling expense* together constitute the *general overhead* of the business.

Operating profit is that profit which is realized from the operations of the business proper and exclusive of subsidiary operations from which arise other income and other expenditures.

Net profit is that sum which is added to the surplus of the business and as such is available for dividends and other corporate expense.

Particular attention is called to the fact that the expenditures and profits just indicated are only those which obtain for a given volume of sales and for a given plant output, and by no means should any such percentages or ratios be taken as constant for a wide range of sales. A great error will be made in forecasting the probable earnings of the business if it is assumed that the net profits on *all* sales will be 16.9 percent, as the above data show to be the case only for a given volume of business done at a given time.

The monthly profit and loss statement is supposed to constitute a record of the results of the economic performance of a business for a given month. This is not strictly correct. The statement records the results on the *business concluded* during the month. In the first place, as was noted above, the basis of the record is sales for the month, that is, goods shipped and billed to the customer. The orders for the goods shipped may have been booked the preceding month or several months before. Therefore, it may happen that the orders booked for the past several months may actually be declining and yet the sales as recorded in the profit and loss statement may be showing an increase during the same period.

The "cost of sales," or the cost of manufacture of the goods sold, may not have been incurred during the month to which the profit and loss statement relates. In fact, the costs recorded may have been incurred many months before. In the manufacture of typewriters, for example, it is common practice for certain lots of small parts to be manufactured in quantities sufficient for several months' supply because the set-up time of the presses constitutes a large portion of the cost of processing and, hence, it is more economical to produce a large quantity per set-up and store the parts for subsequent assembly. The cost of the lot thus processed will be made up as to materials, labor, and factory expense (estimated) and divided by the number in the lot to determine the cost per unit. When the part is withdrawn from semifinished stores for assembly at a later date, the cost is accrued to the lot of machines assembled, and when any of this lot of assembled machines is shipped at a still later date, it is this cost which was incurred some time before, which finds its way into the record cost of sales. Accordingly, the record "cost of sales" in the profit and loss statement does not necessarily show the expenses either paid for in cash or incurred during the month on account of goods manufactured

in that month. Assume, for example, that a factory is shut down for vacation in August of any year and that there is no production. Assume that the order and shipping departments, however, are not on vacation—so that customers' requirements may be attended to. Accordingly, the "sales" for August may be $500,000, say, and the profit and loss statement for the month may show a cost of sales of $350,000, yet no expenditure was incurred during the month for direct labor.

The same situation exists in regard to administrative expense and selling expense. A company may order a year's supply of catalogues, for example, and pay for them in the fall, yet it may be decided to apportion this expense to each month of the following year, in which case part of the selling expense recorded in any month may relate to an actual expenditure made several months prior.

Thus it will be apparent that the monthly profit and loss statement of a company may not indicate its current performance in the matter of either expenses incurred or orders booked. It should be noted also that none of the items of the profit and loss statement indicates cash transactions. In the above statement, in which the net profit is shown to be $144,713.12, it is not to be inferred that the company has increased its cash during the month by the amount of the profit. Profit has no relation to the cash position. In fact, it may happen that a company showing a net profit of $144,713.12 in a given month may have less cash at the end than at the beginning of the month.

C. PROPRIETORSHIP

The inclusion of a condensed profit and loss account in the balance sheet statement under the heading of *Proprietorship* is advocated by such an authority as Dr. Roy B. Kester, Professor of Accounting, School of Business, Columbia University.* It has considerable merit from the standpoint of clear statement. According to this method of statement, a balance sheet would appear as in Table IV.

This form of statement shows at a glance the principal facts of a business, particularly as to the changes in proprietary interest. The profit and loss statement is in the usual form, though in such a case it is a kind of exhibit to the "proprietorship" section of the balance sheet.

Another important aspect of this kind of presentation is a clearcut division between the liabilities, strictly speaking, i.e., what the business owes to outside creditors and the liabilities of the business to-

* Kester, Roy B. *Principles of Accounting*, 4th Edition, New York, 1939.

TABLE IV

BALANCE SHEET

—— Corporation
August 31, 19—

	Assets	
Cash	$ 148,968.48	
Accounts receivable	217,930.47	
Inventory	288,888.62	
Plant (less depreciation)	1,314,378.26	
Deferred items	35,186.24	
Patents	949,880.04	
TOTAL ASSETS		$2,955,232.11
	Liabilities	
Accounts payable	38,275.89	
Accrued expenses	16,830.41	
Other items	68,891.44	
TOTAL LIABILITIES		123,997.74
	Proprietorship	
Capital stock	2,000,000.00	
Earned surplus	818,382.12	
Net profit for month	12,852.25	
TOTAL PROPRIETORSHIP		2,831,234.37

wards its owners, i.e., the proprietorship. Such a division gives the balance sheet a greater clarity. The immediate consequence is that the fundamental equation of accounting

$$\text{Assets} = \text{Liabilities}$$

is changed into the equation

$$\text{Proprietorship} = \text{Assets} - \text{Liabilities}$$

Thus the net worth is immediately revealed.

D. DEFINITION OF TERMS USED IN READING THE FINANCIAL STATEMENTS

Some of the items of the balance sheet or of the profit and loss statement are often grouped together to give further meaning to the statements. Among them, the following are most used.

1. The *net worth* of a business is the sum of the capital stock issued and the surplus. It represents the amount which the stockholders have in the business.

If the balance sheet is presented in three parts, the net worth is equal to the total of the proprietorship section (see above, page 50).

It may happen, however, that, in good logic, part or all of the *reserves* should be included in *net worth*. This is the case if and when the so-called reserves are, in fact, surplus that are accounted for under the name of reserves. In case of doubt, one should consider the nature of an item rather than the name it is called by.

2. The *debts* of a business represent the amount which the creditors, both long-term and short-term, have at the risk of the business. The sum of net worth, debts, and reserves constitutes the total liabilities.

There are, therefore, two groups of interests which provide capital to operate a business—the stockholders and the creditors. The creditors are also of two classes, i.e., those whose accounts are payable over a period of years, and the short-term creditors who are generally merchandise creditors, banks, and note holders. The long-term creditors are generally those who hold mortgages or bonds.

The management of the finances of a business should be so conducted that there are always sufficient funds on hand to meet its obligations. Accounts receivable should be turned into cash in anticipation of maturing obligations. If current bills are not paid on time, the credit of the organization is impaired and a serious handicap is placed on the conduct of the business.

When accounts receivable are not collectible, as perhaps in a general business depression, the assets of the company are said to be frozen. Creditors press their claims, and the company may be forced into bankruptcy or a receivership to protect its assets. The same situation arises when mortgages must be met and no funds are available to meet them. This condition is very frequently due to poor financial management, in which investments are made in plant extensions to provide improvements or in anticipation of new business, and the new business never materializes. Sometimes large purchases of raw materials are made well in advance of immediate requirements and the bills for these materials must be met before they can be converted into goods and sold. If the market has been misjudged and if bank loans cannot be made to tide over the situation, the company is likely to become embarrassed.

3. The *working capital* of a company consists of the current assets less the current liabilities. Bank loans, if any, should be included in

the current liabilities. Banks generally will renew a note upon partial payment of the principal when due, but it is generally true that the bank will require the borrower to be "off its books" at least once a year. Furthermore, since the bank must be careful not to extend itself, it may be forced to call a loan or demand payment upon maturity. Therefore, it is well to assume that bank loans are current liabilities to be paid within a short period of time.

4. The *capitalization* of a corporation consists of the par value of both the common and preferred stocks which have been issued, plus the face value of the bonds issued. This term is not always clear for the following reasons. If a bond issue is about due for retirement, either in whole or in part, it certainly cannot be considered a permanent investment. If the common stock is of no par value and yet has been sold for a considerable sum of money, this sum does not appear as part of the capitalization. The term has doubtful value.

5. The *capital structure* of a corporation refers to the total funds invested in the business by the bondholders and the stockholders. The stockholders' investment consists of the amounts paid for the stock, either par or no par, and the amount of earnings left in the business through accumulated earnings (surplus) and the capital surplus, if any. This is a changing item due to bond retirements and the declaration of dividends out of earned surplus.

E. CONCLUSION

The principal features of the balance sheet and the profit and loss statement are, as noted above, general records of the state of the values of a business at a particular time and the changes in values which have occurred during stated time periods. The usefulness of these statements as guides to company policy depends, in part, on the *relationships* which these values have to each other and to the operating characteristics of the particular business to which they relate. Accordingly, some interpretation of the relationships between the items of the financial statements must be made. Among these relationships, those known as balance sheet ratios and operating ratios have been generally standardized, and it is now our purpose to define and interpret them.

III

INTERPRETATION OF FINANCIAL STATEMENTS

BALANCE SHEETS and profit and loss statements represent an accounting to the stockholders of the uses made of the funds they have invested in the business. Bondholders and other creditors, particularly commercial banks, are also informed, through these statements, concerning the uses of the funds which they have loaned to the business. The financial statements are certified by authorized public accountants as a guarantee to all those who have put any money into the business, that all funds are properly accounted for. But certain important facts about the business, particularly its stability and the skill of the management, must be determined through a detailed interpretation of the items of these statements. What is meant by an interpretation? It means to give meaning to. Data of themselves convey very limited meaning. They have real meaning only when they are related to or compared to other data. By relationships and comparisons we may determine or measure variations in time, variations in status, variations in performance and

variations from a standard. Thus financial statements supply mainly the raw data which, together with data from other sources, need to be arranged, compared, and measured in order that such statements may yield the information required for policy formation and determining a course of action. A number of methods of comparison and measurement of performance for devising the status and changes in financial values are in common use. These are based on three principal sources of data:

A. Financial ratios
B. Predetermined standards
C. Supplementary data from other company records.

These methods, which we will now examine, are mainly statistical in that they reveal *how* and not functional so as to tell *why*. The functional method of analysis will be developed in a subsequent chapter.

A. FINANCIAL RATIOS

A financial ratio expresses the relationship between items of the financial statements. A comparison of these ratios among themselves is used to portray certain aspects of a business.

It is very important for the manager of any business enterprise to know the acceptable values which each of the ratios should have for the particular business that he is managing. These ratios are not constant for all businesses; that is, a ratio which indicates a healthy condition in one business is wholly inadequate for another business. Therefore, these ratios are not to be considered as absolute measures but as *indicators,* which, together with other factors, show the general status of the business. In general, the ratios are useful in revealing certain aspects of the business, relating to:

1. The financial structure
2. The financial management
3. The efficiency of operations
4. The result of operations.

1. THE FINANCIAL STRUCTURE

A business may acquire its finances through the stock subscriptions of its owners, the reinvestment of its earnings, and loans by its creditors. The owners and the creditors of different classes both have an interest in the business, but the nature of this interest and the rights and obligations of each are not the same. The proportions in which

these interests exist is significant as to the financial structure, particularly its stability, and the earnings accruing to the different classes of owners. Among the indications of the above nature is:

a. The Ratio of Net Worth to Total Assets. This ratio shows the extent to which the stockholders own the business. From one standpoint, it is good business to borrow money at 4 percent and utilize it in a business at a profit of 20 percent. The difficulty in such a situation is that the creditors from whom money is borrowed are generally secured by instruments which permit them to take drastic measures in case of a default in payment of interest on loans, or the payment of the loan at maturity. It is because of this hazard, by which creditors' claims may become pressing and embarrassing, that it is not well to have too large a proportion of the capital in the business supplied through such sources.

Now, the question in any given business is: How much is too large a proportion? The answer is that there is no general rule, but that the situation should be carefully guarded. The interests of the owners, plus the interests of the bondholders, is termed the *capital structure,* since the funds derived from the owners and the long-term creditors are more permanent in nature than the funds derived from bank loans, short-term notes, and merchandise credit.

The percentage of each class of owners' shares and the bondholders' shares to the total capital structure determines the degree to which the common stock holdings are conservative or speculative. Professors Guthmann and Dougall report the results of a study they made in the combined capital structures of industrial, utility, and railroad corporations, as in Table V.*

TABLE V

CAPITAL STRUCTURES (A)

(Billions of Dollars)

	Industrial		Utilities		Railroads	
	Amount	%	Amount	%	Amount	%
Bonds	$10.6	14	$12.0	40	$11.7	44
Preferred stocks	9.7	13	3.6	12	2.0	8
Common stocks	39.2	51	11.4	38	8.1	31
Surplus	17.5	22	3.1	10	4.5	17
	$77.0	100%	$30.1	100%	$26.3	100%

* Guthmann, H. G. and Dougall, H. E., *Corporate Finance Policy,* New York, 1946.

They also report a similar analysis of different types of businesses, in Table VI following.

TABLE VI

CAPITAL STRUCTURES (B)

Type of Business	No. of Companies	Total Capital Structure (*Millions*)	Percentage			
			Bonds	Preferred	Common plus Surplus	Total
Autos	13	$1,306	1	16	83	100
Chain stores	6	439	7	6	87	100
Chemical (ind)	16	1,293	3	13	84	100
Iron and steel	18	3,071	15	19	66	100
Machinery	24	860	6	23	71	100
Mail order	3	375	3	6	91	100
Meat packing	4	674	35	13	52	100
Petroleum	26	6,206	13	4	83	100
Rubber	9	563	31	39	30	100
Sugar	8	277	1	27	72	100
Theater and motion picture	3	278	40	8	52	100
Tobacco	6	635	9	14	77	100

The records show that there is a wide variation in practice as to the composition of the capital structure among different types of businesses. The important meaning of the composition of the capital structure to the investor may be illustrated by the following example:

Let us assume that a company, in a given year, earns $1,000,000 on a capital of $5,000,000. Its earnings would therefore be 20¢ per dollar of capital invested. Assume, however, that the company has a capital structure similar to that of the rubber industry, as given above, and that the bonds bear 5 percent interest and the preferred stock 7 percent cumulative dividends. In that event, the total bond interest payable would be $1,510,000 × 0.05 = $77,500; the preferred dividends payable would be $1,950,000 × 0.07 = $136,500; and the common stock would be entitled to the remainder, or $786,000. Assuming, for purposes of illustration, that 50 percent of the common stock plus surplus is common stock, then the amount of common stock would be 15 percent of $5,000,000, or $750,000, and it would then earn at the rate of

$$\frac{786{,}000}{750{,}000} = 105\% +$$

If now the company had a capital structure similar to that of the mail-order business, and its common stock was also 45½ percent of its capital structure, then for the same rates of bond interest and preferred dividends as before, the amount of bond interest would be $5,000,000 · .03 · .05 = $7,500; the preferred dividends payable would be 5,000,000 · .06 · .07 = $21,000; and the earnings on the common stock would be $1,000,000 — $7,500 — $21,000 = $971,500. Since the common stock is 45½ percent of $5,000,000 = $2,275,000, the percentage earned on the common stock would be

$$\frac{971,500}{2,275,000} = 42.6\%$$

Accordingly, while each company may earn 20 percent on its capital, the common stockholders, in each case, would fare quite differently, according to the details of the capital structure. In the above examples it was assumed that 50 percent of the common stock plus surplus was common stock, and the earnings on the common stock were determined accordingly. But, since the surplus is also owned by the common stockholder, it appears that in this case his investment in the business is really twice as great as the book value of the stock. Therefore, the real percentage earnings of the *investment* of the common stockholder in the above example is half the percentages stated.

b. The Ratio of Debt to Net Worth. This ratio shows another characteristic of the financial structure and reveals the extent to which the creditors (both long-term and short-term) and the owners have each contributed to the funds used in the business. If, for example, in a given manufacturing business the debts should amount to $3,450,000 and the net worth should be $3,000,000, it appears that for every dollar the owners supplied, the creditors supplied $1.15. Because of the nature of creditors' claims on the assets in case of defaults in payment of their claims, the above ratio represents an unstable and hazardous structure.

In the utilities and railroads, the bonded debt is relatively high because of the control which the public authorities exercise on the issuance of their securities which restricts stock issues. Also, because of such control and supervision, a large funded debt is not considered a hazard to the financial structure.

c. The Ratio of Corporate Funds from Internal Sources to Total Corporate Funds. This ratio is frequently referred to in banking circles and is coming to have more meaning in evaluating the financial policies of corporations.

Funds from internal sources are those which are derived from earnings and depreciation accruals as well as from profits on the sale of fixed assets and investments, tax refunds and renegotiation receipts. This fund is lessened by cash dividends and net decreases in cash balances, marketable securities, trade notes, accounts receivable, inventories, and in other assets.

Funds from external sources are derived from credit advances by banks, by suppliers of merchandise on open accounts or trade acceptances, by bond and noteholders. It may also be augmented by the issuance of additional capital stock.

The total corporate funds are those derived from both internal and external sources.

The ratio of corporate funds from internal sources to the total corporate funds is an expression of management's policy in the creation of the capital structure of the business and in financing its current needs. It measures, in fact, the degree of financial independence of management from the various creditors *and* from the stockholders. The size of this ratio, as of the other ratios previously considered, varies widely among businesses. A survey recently published by the Federal Reserve Board * and covering 14 industries tabulated below (Table VII) shows how these ratios varied among the different industries, and how they changed from 1946 to 1947.

TABLE VII

INTERNAL SOURCES OF CORPORATE FUNDS
AS PERCENTAGE OF TOTAL RESOURCES
1946–1947

	Year	
Industry	1947	1946
Food	66%	85%
Tobacco	21	21
Rubber	49	84
Petroleum	63	79
Chemicals	44	70
Iron and steel	60	75
Non-ferrous metals	53	78
Machinery (including electrical)	42	63
Automobiles	45	60
Other transportation equipment	74	72
Retail trade	79	74
Railroads	72	100
Electric and gas utilities	58	72
Communication	17	37

* *Federal Reserve Bulletin*, June, 1948.

These figures show that during the year 1946 the internal source of funds accounted for more than 70 percent of the total corporate funds in most industries. In 1947, the proportion, although substantially lower than in 1946, is still quite large and is about 50 percent on the average. Mr. Charles H. Schmidt, commenting on these ratios,* stated:

> Corporate profits were at record levels during 1946–1947 in most industries and dividend payments to stockholders were not increased in proportion to earnings. As a result, retained earnings provided two-thirds or more of the internal funds obtained by large corporations in 9 of the 14 industries.
>
> In 1947, over 61 percent of profits after taxes were retained and invested as compared to 55 percent in 1946 and only 31 percent in 1929. Aggregate undistributed corporate profits totaled approximately $11 billions in 1947 compared to $7 billions in 1946 and $2.5 billions in 1929.

2. THE FINANCIAL MANAGEMENT

The life of a business is always subject to the skill with which its finances are managed. Even though a particular business may be operating satisfactorily as to production, costs and profits, these characteristics alone are not completely indicative of its management. The elements of its financial status must be in satisfactory balance with one another to assure a strong financial condition. The financial management may therefore be judged by the relationship between the items of the financial statements. The following ratios serve as such indicators.

a. *The ratio of current assets to current liabilities* is generally considered to be an indicator of the ability of the company to pay its current debts promptly. In passing judgment on this ratio in any given case, care must be exercised on the following matters. Since current assets are made up principally of cash, accounts receivable, and inventory, it can readily be seen that a company having current assets mainly in cash is in a far different position from one having current assets mainly in inventory of raw materials in great excess of current requirements, although both companies may have the same ratio.

b. *The acid test,* which is the *ratio of current assets less inventories to current liabilities,* partially answers this objection, by eliminating the inventory factor. But, still, it is evident that a company having receivables which are long past due cannot be said to have a current asset which is readily converted into cash. Therefore, the acid test by itself is not a conclusive indicator of a company's current position.

* *Federal Reserve Bulletin,* June, 1948.

c. *The ratio of receivables to annual sales* may be helpful in this respect, since it measures the care with which credit has been extended and the diligence of the officer responsible for collections. (More precisely, the average collection period, or the average number of days necessary to collect from customers, is equal to the above ratio, receivables to annual sales, multiplied by 360.)

It is current business practice to pay all bills within 30 days. A discount for payment within 10 days is usually allowed. Incidentally, it may be noted that the allowance of such discounts is generally an expensive method of collecting accounts.

If a company has more than 30-day business in its accounts receivable, it is generally a sign of weakness in the credit and collection departments. This, however, is not always so. Sometimes it is necessary to extend long credits. In the sale of fertilizer to southern farmers, the material is delivered in the spring and planters' notes are given for payment when the cotton is ginned in the fall. If the cotton crop is not good, the notes are not paid in full. In the automobile business it was found prohibitive to extend long credits, because it required altogether too much working capital, and so credit or finance corporations were formed to handle the purchasers' notes. However, one of the great economic problems facing us is the direction of credit to production channels and the restriction of credit to those who are inclined to live beyond their incomes. It is so easy to buy goods on the instalment plan and finance purchases through discount houses that the people in general are mortgaging their earnings too far in advance. There is consequently a false stimulus to business which is sure to have a bad reaction. For a business which deals with a wide market, the ratio of receivables to annual sales should not be greater than about 10 percent, but for businesses which deal with a seasonal market there is generally a tendency to extend credit and the ratio may be higher and yet conform with good business practice. However, it is not to be forgotten that the longer the credit the greater the hazard.

Finally, to give full meaning to the above ratios, weight must be given to the nature and size of inventory, and to the state of the individual accounts receivable.

d. *The ratio of cash to current liabilities,* which establishes the cash position of a company, is generally considered satisfactory if it is about 25 percent. This assumes that the business is not seasonal. If a large quantity of merchandise or material is purchased for conversion into salable products to be marketed at a distant date, it will be evi-

dent that cash income will be deferred and, therefore, a ratio of 25 percent may not be adequate, because bills must be met before money is received from the sale of the product. Such situations must be analyzed and set up in the form of a budget of income and expenses before one may be assured that adequate cash is provided to meet current bills.

e. *The ratio of reserves to total assets* is not a particularly significant ratio without some information regarding the peculiar hazards of the business.

In general, a reserve item is a withdrawal from the surplus account in anticipation of an expenditure which events indicate may have to be met. Reserves may be set up in anticipation of the renewal of equipment. Such a reserve is known as a depreciation reserve. Reserves may be set up for bad debts. In times of depression, this reserve should be larger than in normal times.

If a company is threatened with a civil suit on account of alleged patent infringements, a reserve should be set up immediately in anticipation of this event. If a company is engaged in manufacturing a product, of which the art is very active, that is, many inventions are constantly being made in this field, it may be necessary to set aside a reserve for the purchase of patents or for research to develop new products or improve the present one.

Any number of circumstances, therefore, may demand the establishment of a reserve. Since dividends are payable from surplus only, the real significance of a reserve is to prevent the taking of money out of the business in greater amounts than the future needs of the business in the matter of contingent demands for funds may warrant.

A very important matter in connection with setting up reserves is frequently overlooked, namely, that, when a reserve is set up, it becomes in effect a lien against cash, and, therefore, the cash items should bear some relation to the reserve. Suppose, for example, that a reserve of $250,000 is set up in anticipation of an expenditure and it should happen that this expenditure must be made. If cash on hand is only $40,000, and just sufficient for current requirements, it is evident that the situation can be met only by bank borrowings or the negotiation of a loan.

Now, this does not imply that cash on hand must always equal the amount of the reserves plus current needs, but what is required is that the amount and nature of the reserves should have some bearing on the amount of cash on hand. A reserve should always be supported by adequate cash. Just what amount is adequate will depend on the probability of having to meet the situation for which the reserve was created.

In general, a reserve is set up to protect the total assets, but the ratio which should obtain in any given instance cannot be definitely established.

3. THE EFFICIENCY OF OPERATIONS

Given a certain organization, management may operate it with more or less efficiency, which can be measured directly by the total amount of production and the reduction of cost, or indirectly by (a) turnover ratios, and (b) cost ratios.

a. Turnover Ratios

(1) *The ratio of the inventory to sales* is, to some extent, a measure of a company's purchasing and production policies. Inventory, it will be recalled, is made up of raw materials, work in process, and finished goods. The time of converting raw materials into finished products and the availability of raw materials throughout the year are important factors in passing judgment on this ratio. The inventory required by a foundry making gray iron castings from pig iron, which may be purchased any day, is quite different from that required by a manufacturer of industrial alcohol from molasses, which is purchased when the crop is available.

A shirt manufacturer will begin in June the production of shirts which are to be delivered in the fall, and for which he has previously purchased his materials, or at least made his commitments. It may take two months to make an engineer's level, but a loaf of bread is baked in a day. Therefore, the inventory requirements in respect of work in process are quite different in these two industries.

A large inventory of sugar in a rising market is quite different from one in a falling market. Therefore, the ratio of inventory to sales must be judged on the basis of the requirements of the business and the characteristic features of both the buying and selling markets in which the business functions.

(2) *The ratio of annual sales to net worth* measures the activity of the money which the stockholders have at the risk of the business. In general, the higher the ratio, the better the investment. The ratio is preferably greater than 200 percent because lower ratios are generally indicative of a hazard to the margin of profit. When the ratio is high it indicates that the business has some slack, that is, there can be a drop in sales without the same consequence to profits as when the ratio is low.

(3) *The ratio of sales to fixed assets* indicates the vitality of the fixed assets. It also is a measure of a wide or narrow range of sales at a profit. If the ratio is high, it generally indicates that there are low fixed charges on the business, and, therefore, the break-even point is low, with a consequent wide range of sales at a profit. A low ratio, on the other hand, shows a high fixed charge and a narrow range of sales at which a profit can be made. A business with a low ratio is more likely to get into trouble during a period of depression than a business with a high ratio. On the other hand, given two similar businesses, the one with higher fixed assets will, other things being equal, probably have better possibilities of mass production at low cost and, in time of expansion, will be in a better position to earn larger profits.

b. Cost Ratios

The profit and loss statement of a given business may read as in Table VIII following.

TABLE VIII

STATEMENT OF PROFIT AND LOSS

—— CORPORATION

Month of August, 19—

Sales (net)		$191,957.97	100.0%
Cost of manufacture		160,468.34	83.5
Gross profit		31,489.63	16.5
Administrative and selling expense			
Administrative	$12,226.34		
Selling	6,455.84	18,682.18	9.2
Operating profit		12,807.45	6.8
Other income	1,282.17		
Other expenses	1,237.37		
Net		+ 44.80	
NET PROFIT		$ 12,852.25	6.8 +

The percentages show that for every dollar of income received during August, the cost of manufacture absorbed 83.5¢, leaving a gross profit of 16.5¢. The administrative and selling expenses absorbed 9.7¢, leaving an operating profit of 6.8¢. The net of other income and other expense is very small so that the net profit is practically the same as

the operating profit. If the cost of manufacture is broken down into its elements, it will appear as follows:

	Cost of manufacture	
Labor	$ 60,563.20	31.6%
Materials	42,580.40	22.2
Factory expense	57,324.74	29.7
	$160,468.34	83.5

This analysis shows that for every dollar of income received, 31.6¢ was paid to direct labor,* 22.2¢ was paid for materials, and 29.7¢ for factory expense.*

The important operating ratios derived from the profit and loss statement are accordingly:

(1) Ratio of cost of manufacture to sales
(2) " " labor cost " "
(3) " " material cost " "
(4) " " factory expense " "
(5) " " administrative expense " "
(6) " " selling expense " "

These ratios in any business will vary from month to month with sales for reasons which will be disclosed in Chapter XII, which deals with the problem of costs at varying rates of production and sales.

Every engineer knows that no two machines should be treated alike. Some need one sort of care and others require different handling. A steam turbine, for example, must be run with a comparatively high vacuum on the condenser to obtain a maximum economy in steam consumption. A reciprocating steam engine, on the other hand, may not be so materially affected by vacuum conditions as a turbine. A uniflow engine may be operated over a wide range of loads with little change in steam economy, whereas another type of reciprocating engine must run near its rated capacity, since when run at any load above or below its rated capacity a material increase in steam consumption will result. The electrical engineer knows that it is not desirable to use a 10-hp. motor to operate a 2-hp. load, because the current consumption is too great.

Every business has certain characteristics of operation which should be fully understood if they are to be completely controlled. Some of

* For the precise definition of these terms, see Chapter X.

these characteristics are revealed by the operating statement. The above statement shows the following interesting facts about the business to which it relates:

(1) The manufacturing division of the business occasions the greatest amount of expense.
(2) The most fertile field in which to attempt to effect economies is in the production division.
(3) The selling division of the business is not very costly to operate, and, therefore, if all departments of the business are well balanced and the plant is running to capacity, there is not much effort to devote to effecting economies in selling, if expenses have to be reduced for one reason or another.
(4) In general, the margin of profit in this business is largely controlled by efficient factory methods, and therefore this business needs the very best type of factory superintendent.

It is always well to bear in mind that the margin between success and failure is generally very narrow. Any errors in judgment on the part of the sales department in pricing goods, added to errors in judgment in purchasing materials at unfavorable prices, plus errors in judgment in determining methods of processing, in addition to errors in judgment in setting piece rates in the factory, etc., may, through their cumulative effect, completely wipe out an otherwise good margin of profit.

Often the situation is saved through the operation of the law of probability, which provides that all mistakes are not likely to happen at the same time. On the other hand, it is equally true that the law of averages provides that *some* of these mistakes continually occurring prevent a 15 percent profit from becoming a 20 percent profit. It does not always follow that because a business may make a profit of 15 percent, for example, and everybody is satisfied because the business has never been any more profitable, that it could not be made to earn a 20 percent or even a 25 percent profit, if it were managed better. Unfortunately, rational methods for measuring the maximum earning capacity of a given business are not generally employed, and, therefore, under those circumstances, there can be no definite standards by which the management of a business may be accurately judged. But there is no business, no matter how complicated its operations may seem, which cannot be analyzed and have standard

costs set for its many detailed operations. An approach to the methods to follow will be indicated in Part B of this chapter.

4. THE RESULT OF OPERATIONS

In the final analysis, the value of a business is measured by the amount of profit that is made. Two ratios are of current use: (a) *the ratio of profit (or loss) to the invested capital, and* (b) *the ratio of profit (or loss) to sales.*

The first one was, in the past, almost exclusively and is still today the most currently used. Lately, business groups have been inclined to prefer the second. Much discussion has been going on as to their respective values. From a scientific point of view, they are both useful. The ratio profit (or loss) to the invested capital has the definite advantage of reflecting the turnover of the capital, and, therefore, of giving a better measure of the final result; also makes it possible to forecast the probable return of an investment in a given line of business.

Finally, it may be said that the ratio profit-to-sales may be misleading when a comparison is made of results over a span of years. This year the ratio is 10 percent of sales. Last year it was 15 percent. "What is the matter with us?" the members of the board will say at the January meeting. Neglecting to compare the total sales for this year with the total sales for last year, they ignore that the ratio *cannot* remain constant if the structure of the business is unchanged, and if the total sales do change substantially. The fact is that sales and expenses do *not* vary proportionally, as will be shown in the following chapter, when the ratio total-expenses-to-total-sales is studied. Such a ratio is obviously another form of the ratio profit-to-sales.

Both ratios, profit-to-sales and profit-to-invested-capital, moreover, fail to disclose certain hazards to the business and therefore cannot be used in determining important tendencies of the business. For instance, when profits arise from several sources it may be helpful to determine this ratio for each source, in order to learn the extent to which each product or source of income contributes to the profits of the business as a whole.

Referring to the above ratios, in general, it may be stated that it is always helpful to compare similar ratios for a series of balance sheets to determine the tendencies of the business, for, although a given set of ratios may seem favorable for a given balance sheet, if they are *tending* in a wrong direction, there is something wrong with the business which demands correction.

It is helpful to realize that an analysis of the above nature is generally made by the banker whenever a company is negotiating for a loan, particularly if the bank has not had much experience with the borrower. Accordingly, it is helpful if the borrower makes such an analysis himself and supplies such explanations as the results of the analysis may warrant before making applications for the loan.

When the invested capital consists of bonds, preferred stocks, and common stocks, a further analysis is usually made with respect to each class of security. Such ratios are:

a. Earnings divided by bond interest. Since bonds have a prior lien on earnings, the margin of safety of the bonds may be expressed in terms of the ratio of the amount of bond interest to the amount of earnings.

b. Earnings minus bond interest payable, divided by the preferred dividends payable, measures the amount of times the dividend on the preferred stocks have been earned.

c. The percentage earnings on the common stock is found by dividing the earnings, after payments of bond interest and preferred stock dividends, by the number of shares of common stock outstanding.

B. PREDETERMINED STANDARDS

Such standards may be either based wholly on the results of past performances of the business, or established on more scientific basis of estimates.

1. Past Performances

When the balance sheet of a company as of a given date is compared with its balance sheet as of another date, many changes in values of the items will be found. A company's statements of assets and liabilities as of 1946 and 1945 will show value changes which took place during 1946. If the net worth has increased during the year, that is, the net worth before dividend disbursements from surplus, the business has been conducted at a profit; and if it has decreased, the business has been unprofitable.

The comparative balance sheet statement for the months of July and August 19— of the company to which the profit and loss statement in Table VIII relates is given in Table IX.

TABLE IX

COMPARATIVE BALANCE SHEETS

——— Corporation

Comparative Balance Sheet as at
August 31, 19– and July 31, 19–

Assets	*August 31*	*July 31*	*Increase or Decrease*
Current			
Cash	$ 148,968.48	$ 132,940.27	$ 16,028.21
Accounts receivable	217,930.47	217,585.99	344.48
Inventory	288,888.62	303,012.51	–14,123.89
Fixed			
Properties less depreciation	1,314,378.26	1,312,338.29	2,039.97
Other			
Deferred items	35,186.24	36,266.42	–1,080.18
Patents, etc.	949,880.04	949,880.04	———
Total	2,955,232.11	2,952,023.52	3,208.59
Liabilities			
Accounts payable	38,275.89	44,605.90	–6,330.01
Accrued liabilities	16,830.41	20,691.33	–3,860.92
Other	68,891.44	68,344.17	547.27
Total	123,997.74	133,641.40	–9,643.66
Capital and Surplus			
Capital stock	1,500,000.00	1,500,000.00	———
Surplus	331,234.37	318,382.12	12,852.25
TOTAL	2,955,232.11	2,952,023.52	3,208.59

This statement shows what has happened to the values of both assets items and liabilities items during the month. The change noted in the surplus ($12,852.25) shows the profit realized during August operations. The disposition of the profits, that is, what was done with the profits, is shown in the other changes. The net change in assets was an increase of $3,208.59, and the net change in liabilities was – $9,643.66.

The profit or loss made during any time period might therefore be learned by comparing the balance sheets at the beginning and end of the period. But this comparison does not enlighten us on the causes of profits or losses. This must be learned from the profit and loss statement directly.

A similar comparison may be made between two balance sheets of successive years. Taking into account the factors that, independent of management's action, may have influenced the conduct of the business (such as changes in general economic conditions, higher wages,

etc.), it will be possible, to a certain extent, to use the previous balance sheet as a yardstick to measure the actual performance.

This, however, assumes that the previous balance is an adequate yardstick, which is not established.

2. *Estimated Standards*

The latest developments in accounting and economic techniques have endeavored to provide such a yardstick established on a scientific basis. It is not the purpose of this study to enter into the details of such techniques, which are the subject of cost accounting. Only the general principles involved will be indicated.

The first step is to determine the standard direct expenses. There are two ways of establishing them. One is to rely on past experiences. But such a method does not provide results fundamentally different from a comparison with the financial statements of previous years.

The other method is to compute the expenses on the basis of scientific studies. The expenses for labor, materials, power and other items incurred for a given rate of production as well as other expenses of operation may be estimated quite accurately by well-known engineering techniques. From these estimates the cost of goods sold for any rate of production may be readily determined. By this means a scientifically determined standard is provided for comparison with actual performance. Such standards must, of course, be revised from time to time to take into account the changes in the values of the economic factors, such as wages and prices on which they are based. From such standards it is possible to set up budgets in all categories of expenses and divisions of operation. The principles and procedures for preparing budgets are dealt with in another volume of this series on managerial control.

C. SUPPLEMENTARY DATA FROM THE COMPANY RECORDS

It is difficult to visualize the trends of a business by means of the financial statements alone, that is, the financial statements do not disclose some facts important to acquiring a broad and comprehensive view of operating conditions. They attempt to disclose what the business has accomplished in a period, in terms of money value.

Practical operating men, however, must look at a business from the standpoint of what is going on in the various divisions of the business in order that *accomplishment* (profit) and *status* (balance sheet) may become satisfactory in time.

The performance of an enterprise may also be measured from the standpoint of the investments and services required to keep a productive (direct-labor) employee at work and by the value of salable goods he produces in a given time. Some years ago one of the writers devised and used a unit of measurement relating to the above facts which has been found of some service in comparing the performance of a given industry from time to time, and in comparing one industry with another. This method is suggested by the following observations:

A workman in a given factory receives a certain annual wage per year. The company produces a quantity of goods which it sells for a certain sum of money. A known quantity of material is consumed in manufacturing the goods. A certain amount of service is rendered to the direct-labor employees during the given year at a given cost. The total plant investment is known. The company employs a certain number of productive or direct-labor employees. The goods produced vary with the number of direct-labor employees at work. In another company all the quantities are different. Therefore, one company will differ from another in the value of goods produced per productive (direct-labor) employee, as well as in the capital invested to permit his being employed.

The question now arises: What is a satisfactory unit of measurement, and what are the significant factors to be measured? Will the number of direct laborers employed during the year be a satisfactory unit? No, because not all the direct laborers have been employed all the time during the year. Will the average number do? No, because the average number does not mean anything. Apparently, we must devise a unit which is representative of a man being continuously employed throughout the year at direct labor. Such a unit (effective direct-labor employee) is the number of direct-labor-hours paid for during the period divided by the number of hours the shop was operating during the period. Since statements of account are balanced monthly and annually in most businesses, these numbers may be conveniently used to represent the monthly and annual status of the business in terms of the unit productive man (effective direct-labor employee). Every manufacturing enterprise of any consequence keeps a record of direct-labor-hours available on a weekly basis, so this unit of measurement can be easily applied. If, for example, the number of productive labor hours paid for in a given industry is 224,000 for a certain month (and the factory operated for 175 hours during the month), it may be stated that 1,280 unit men were employed during the month. The payroll may show 1,540 direct-labor employees

at work during the month, but an examination of each name may show that 40 of them worked only 2 weeks, 50 for 10 days, and a number were out part time because of illness and other causes.

Monthly comparisons are useful in measuring conditions in any particular business. Because of seasonal variations the annual basis is the better for comparing one business with another. The conditions to be measured will vary with different enterprises because some factors are more important in one business than in another. In general, however, the following relationships are useful:

1. Wages per unit man per month
2. Materials cost per unit man per month
3. Factory expense per unit man per month
4. Administrative expense per unit man per month
5. Selling expense per unit man per month
6. Sales value produced per unit man per month
7. Profit per unit man per month
8. Number of service employees per unit man per month
9. Fixed capital per unit man per month
10. Working capital per unit man per month
11. Inventory value per unit man per month.

Suppose these ratios are found. What good are they? What can be done about it? The answer is—nothing, unless it is also known *what these ratios should be,* and what is to be done to bring them up to standard. All measurements are comparative. If there is no standard of comparison there can be no measurement and therefore no managerial control in the true sense of that term. Performance and the state of things may be compared with other performances and states of things, and we find that one is more or less than the other. But how much do they vary from what they should be? That is the question. The "what should be" is the standard.

A salesman once sought the approval of one of the writers because he had increased sales 100 percent in a territory in which he had recently been installed. By his standards (past records) he did well. His standards, however, were wrong, for the territory had a much greater potentiality—he should have done three times the amount of business he did. His standards were too low.

As a general rule it is very difficult to determine at the outset the maximum standard of accomplishment and the minimum costs required in each department of a business over a given period of time.

Attempts to measure performance in terms of the unit productive

man are best made on the basis of present conditions and, by a continued study of operating conditions, gradually to bring about improvement and strive for higher standards. But it is essential, if a business is to be brought up to its highest state of efficiency, to have standards of accomplishment which are possible of attainment. Let us take a current operating report and put it in a form to show the characteristics of the business on the basis of the unit productive man.

A given business, manufacturing and marketing a machine shop product, shows the following performance for the month (round numbers used):

TABLE X

MONTHLY STATEMENT

——— Inc.

Sales		$187,500
Labor	$ 15,625	
Material	100,000	
Factory expense	25,000	
Total cost of sales		140,625
Gross profit		46,875
Administrative expense	2,250	
Selling expense	10,000	
Total general expense		12,250
Operating profit		34,625

Operating records show that there were:

1. 21,875 direct-labor-hours
2. 15,000 indirect-labor-hours
3. 200 shop hours.

Let a unit productive man be represented by 200 direct-labor hours. Accordingly, the 21,875 direct-labor-hours will represent the equivalent of 110 men continuously employed during the month at direct labor. This record shows that, for every man (unit man) employed during the month, goods to the value of $1,745 were produced and sold, and that it cost to maintain this man:

Wages for labor	$ 142.00
Materials for product	910.00
Factory expense	227.00
Administrative expense	20.00
Selling expense	91.00
TOTAL	$1,390.00

For every dollar paid the man in wages, the company supplied him with \$6.40 of material to work upon and furnished him with services to the amount of \$2.38.

The indirect labor record shows that every group of approximately four men employed at direct labor had three men to serve them in various capacities. The balance sheet of the company shows an investment in fixed assets of \$500,000. Therefore, the company invested \$4,545 for each man employed at direct labor. The company makes a profit of \$315 per month on each productive man.

A certain manufacturer of electrical instruments maintained the following average monthly record during a certain year:

Monthly Performance per Unit Man:

Sales	\$1,200
Wages for labor	112
Materials for product	342
Factory expense	274
Administrative expense	65
Selling expense	252
Profit	155

Every group of five operators employed at direct labor had seven operators to serve them. The company had \$4,160 invested in plant for each direct-labor employee, and the working capital invested was \$5,050.

The value of such an analysis is based on the proposition that the quantity of goods produced and sold during a given period of time by any company will depend upon the number of men employed at direct labor engaged in producing the goods. The profits will depend on how much it costs to keep the man at work both in wages paid and services rendered to help him do the work and to get the orders for him to work on.

Each division of a business may be analyzed in the same manner as the business as a whole, and each division manager will then have a method of measurement to guide him. The value of ratios such as the above in comparing one industry with another is at once apparent. Modifications and subdivisions of the above ratios, as required for any particular business, will immediately suggest themselves when a study of that business is undertaken. The important problem is finding the principal indications of business trend and establishing simple, convenient methods of getting the facts about them.

APPENDIX

Some significant ratios reported by the Federal Trade Commission and Securities and Exchange Commission in their "Quarterly Industrial Financial Report" series for all United States manufacturing corporations, issued July 15, 1948, are summarized below.

1. Profit per Dollar of Stockholder's Equity—1947

Assets Class (*Thousands of Dollars*)	Annual Profits Before Taxes	Annual Profits After Taxes
All sizes	25.5%	15.6%
1–249	23.8	14.3
250–999	29.6	17.0
1,000–4,999	31.2	18.5
5,000–99,999	28.3	17.1
100,000 and over	21.0	13.4

2. Profits per Dollar Sales 3rd and 4th Quarter 1947

Assets Class (*Thousands of Dollars*)	Before Taxes		After Taxes	
	3rd	4th	3rd	4th
All sizes	10.6	10.1¢	6.5	6.2
1–249	7.8	2.6	5.0	1.0
250–999	9.1	6.5	5.4	3.5
1,000–4,999	10.3	8.3	6.2	4.7
5,000–99,999	11.3	11.1	6.8	6.7
100,000 and over	10.8	11.7	6.8	7.6

3. Ratio of Current Assets to Current Liabilities 4th Quarter 1947

Assets Class (*Thousands of Dollars*)	Ratio
All sizes	2.67
1–249	2.20
250–999	2.42
1,000–4,999	2.49
5,000–99,999	2.66
100,000 and over	2.87

4. Ratio of Cash Plus Government Securities
to Current Liabilities
4th Quarter 1947

Assets Class (*Thousands of Dollars*)	Ratio
All sizes	0.83
1–249	0.65
250–999	0.74
1,000–4,999	0.70
5,000–99,999	0.76
100,000 and over	1.00

IV

SALES-EXPENSE RELATIONSHIPS

REPORTS on the state of the assets and liabilities of a business at any particular time (the balance sheet), and reports of the use of funds in manufacture and trade over a given time period, with resulting profit or loss (the profit and loss statement), while important documents, are nevertheless not wholly sufficient as guides to managerial policy. Some new dimension must be provided to give the necessary perspective. Such is the aim of the profit and loss chart and the break-even chart.

I. THE PROFIT AND LOSS CHART

Attempts to provide perspective to the course of business usually follow the pattern of graphic portrayal of tabular statements of profit and loss for a period of years and the secular trend—such as charts showing the variation of important items of the financial statements with time. Thus, the charting of trends of sales with time, expenses with time, and profits with time, to mention a few, are intended to

show how the course of a business is tending with respect of these particulars.

Another method used is to set up a tabular statement, showing the ratios of certain items of the profit and loss statements, such as cost of manufacture, cost of materials and cost of labor to sales, month by month or year by year. To illustrate, let us examine the comparative profit and loss statement for the beverage industry for 74 manufacturers in the $250,000–$1,000,000 assets group for the years 1941 to 1945, published by the Federal Trade Commission in its "Wartime Costs and Profits for Manufacturing Corporations" Appendix, on October 6, 1947 (Table XI).

TABLE XI

COMPARATIVE FINANCIAL STATEMENTS, 1941–1945, FOR THE BEVERAGE INDUSTRY FOR 74 IDENTICAL MANUFACTURERS IN THE $250,000–$1,000,000 ASSETS GROUP

Comparative Profit and Loss Statement

Item	1945	1944	1943	1942	1941
			(Thousands of Dollars)		
1. Net sales	$130,440	$123,905	$102,113	$74,868	$63,392
2. Materials used	41.383	41,463	31,332	19,962	15,622
3. Labor	9,697	9,262	7,766	5,670	4,738
4. Other manufacturing cost	50,602	46,588	37,617	29,459	25,819
5. Net change in inventories	157	798	73	297	221
6. Cost of goods sold	101,839	96,515	76,642	54.794	45,958
7. Gross profit on sales	28.601	27,390	25,471	20,074	17,434
8. Selling, general, and administrative expenses	18,308	16,348	15,008	14,175	14,011
9. Net operating profit	10.293	11,042	10.463	5,899	3,423
10. Non-operating income	523	515	438	411	331
11. Interest and other expenses on long-term debt	44	54	57	94	113
12. Other deductions excluding interest on long-term debt	396	545	866	471	441
13. Net income before taxes and special reserves	10,376	10,958	9,978	5,745	3,200
14. Income and excess-profits taxes	6,588	6,943	5,811	2,876	1,227
15. *Net income after taxes and before special reserves*	3,788	4,015	4,167	2,869	1,973
16. Cash dividends	1,711	1,779	1,657	1,301	1,051
17. Depreciation, depletion, and amortization	1,849	1,858	1,936	1,903	1,838
18. Management salaries	2,238	1,975	1,910	1,711	1,556

As we examine this tabular statement we find that the mass of data does not indicate much more than the fact that such items as net sales, expenses and profits have increased during these years, and net increases after taxes and before special reserves increased from 1941 to 1943 and declined in 1944 and 1945.

If we plot certain of these items, such as net sales, cost of goods sold, materials and labor by years, we obtain the chart of secular trend as shown in Figure 8. The series of four lines shown on this chart indicate irregular behaviors in time. If we tabulate certain ratios of expenses to sales, we find the following (Table XII):

TABLE XII
THE BEVERAGE INDUSTRY
$250,000–$1,000,000 Assets Group
1941–1945
Ratios of Expenses to Sales

	1941	1942	1943	1944	1945
$\frac{\text{Cost of Goods sold}}{\text{Sales}}$	72.5%	73.3%	75.0%	78.0%	78.5%
$\frac{\text{Materials}}{\text{Sales}}$	21.4%	26.7%	30.7%	33.4%	31.6%
$\frac{\text{Labor}}{\text{Sales}}$	7.47%	7.6%	7.6%	7.46%	7.46%

These ratios indicate that the ratio of cost of goods to net sales has increased from 1941 to 1945; that the ratio of materials to sales also increased from 1941 to 1944 but declined in 1945 from what it was in 1944; and that the ratio of labor to sales was fairly constant. But these tabular statements, together with the chart (Figure 8) do not indicate *why* the variations of expense in relation to sales have occurred. They do not establish any basis for forecasting such variations nor for estimating the probabilities of the amounts of such expenses with a given net sales. They are therefore mainly historical documents of limited usefulness for anticipating the financial needs of the business as sales either increase or decline or for exercising managerial control.

Is there any way in which these data may be made to reveal the information needed by the businessman, for forecasting the financial requirements of the business as to the different classes of expenses to

be incurred as sales either increase or decline or for exercising managerial control? If there is such a way, it must be by establishing some functional basis for relating the data of the profit and loss statements.

Figure 8 suggests that as sales increase with the years, the expenses increase also. It also indicates some similarity in the *forms* of the secular trends in expenses and the *form* of the secular trend in sales.

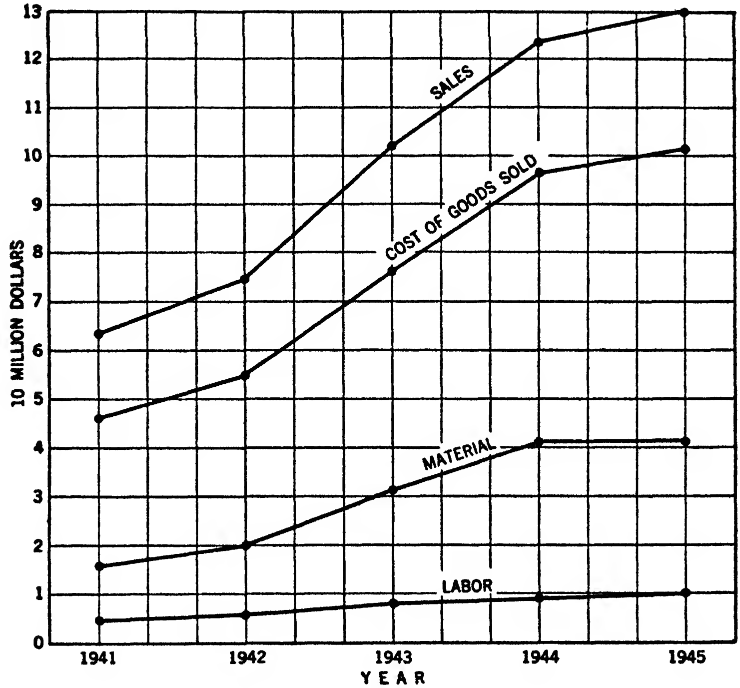

Figure 8. Beverage Industry Secular Trends, 1941–1945, ($250,000–$1,000,000 Assets Group)

This seems reasonable since experience teaches us that expenses and sales go hand in hand. This suggests that there must be some functional or dependent relationship between expenses and sales. Is there any regularity in this dependence? If so, it appears to be functional; a direct cause and effect relationship. Let us try this suggestion by plotting expenses in relation to sales.

Let us plot three items of expense in this manner. This is done in Figure 9 and, interestingly enough, it is found that these expenses are very definitely and specifically related to sales. In fact, each of

these items of expense, when plotted against sales, falls along a straight line of central tendency. When, therefore, the relations of expenses to sales are examined functionally instead of in time perspective, a new meaning is given to them. This new meaning not only informs us as to "how" but also as to "the reasons for how much." The "reasons for how much" is the new dimension which is given the data of the profit and loss statements.* Not only does the chart Figure 9

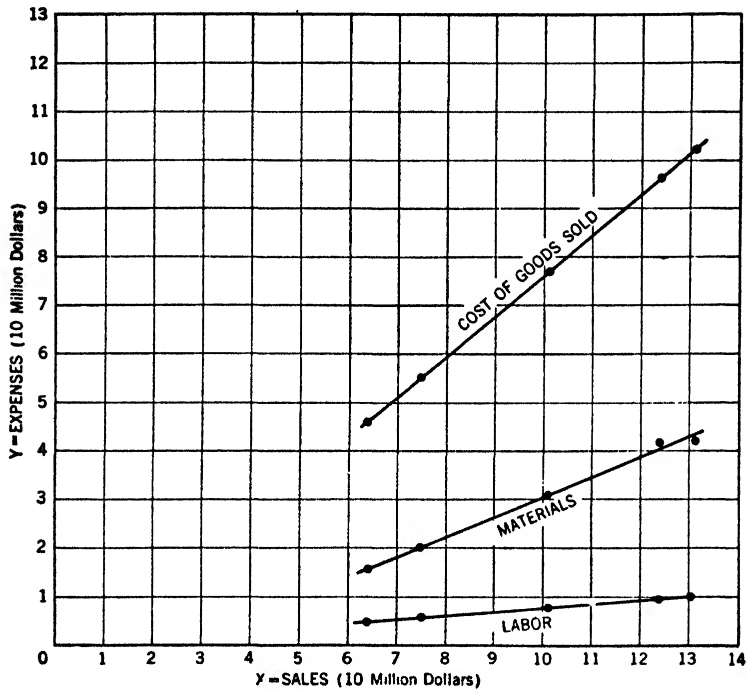

Figure 9. Beverage Industry Expenses vs. Sales, 1941–1945, ($250,000–$1,000,000 Assets Group)

reveal a consistent trend for each item of expense in relation to sales but it also enables us to determine these relationships *quantitatively*. This may be done as follows.

In the case of the trend line of the cost of goods sold it is found from the chart that when Sales $x = 65$ millions, the Cost of goods sold $y = 47$ millions, and when Sales $x = 130$ millions, then Cost

* This method of analysis, resulting in the Profit and Loss Chart and the Break-Even Chart, was devised by Rautenstrauch more than 30 years ago.

$y = 101$ millions. Thus the rise of the trend line is $101 - 47 = 54$ millions for an increase in sales of $130 - 65 = 65$ millions. The slope of the trend line is therefore $\frac{54}{65} = 0.83$ or 83 percent. Where would the trend line cross the y-axis if it were extended? This may be found by noting that if the trend line should pass through the origin, the cost for Sales x of 100 millions should then be 83 percent of x or 83 millions. But the chart shows that the cost for sales of 100 millions is actually 76 millions. This, of course, could only occur when the trend line cuts the y-axis at a point $83 - 76 = 7$ millions *below* the origin.

If then -7 be designated by k and 0.83 be designated by v the general equation of trend of expense (e) in relation to Sales x becomes

$$e = k + vx$$

Thus, if the trends of costs or expenses in relation to sales as shown in Figure 9 are computed, it is found that the average tendency of cost or expense to vary with sales in each of these cases is:

Cost of goods sold $e_1 = -7$ million dollars + 83% of sales
Materials $e_2 = -11.5$ million dollars + 42% of sales
Labor $e_3 = 7.5\%$ of sales

The use of equations of trend for all items of cost or expense in forecasting the financial needs of a specific business, as sales are anticipated to rise or fall, will be developed later. At the present time, we must answer the question: Is this a special case? Before placing too much reliance on this method of analysis as a guide for the future, we must assure ourselves that this is not an isolated instance.

Let us, therefore, take a large representative company such as the United States Steel Corporation and examine its profit and loss statements.

The United States Steel Corporation reports the results of its operations from 1902 to date in its annual reports from which are selected the following data of three different periods: the early period from 1902 to 1910, the middle period from 1920 to 1929, and the later period from 1939 to 1945. These periods were selected at random instead of the continuous record to simplify the presentation as to size of chart.

The sales (products and services) and the expenses (before taxes and interest on debt) for each of these periods are as in Table XIII.

TABLE XIII

UNITED STATES STEEL CORPORATION

Year	Sales	Expenses (Before Interest and Taxes)
	(Millions of Dollars)	
1902	423.1	309.1
3	398.2	314.2
4	324.9	261.5
5	409.2	307.2
6	484.0	352.1
7	504.4	363.0
8	331.6	249.2
9	441.1	321.9
10	491.8	364.9
1920	1290.6	1075.4
21	726.0	623.2
22	809.0	705.2
23	1096.5	904.7
24	921.4	763.7
25	1022.0	853.4
26	1082.3	886.4
27	960.5	800.2
28	1005.3	811.5
29	1097.4	830.0
1939	855.9	753.3
40	1079.1	890.2
41	1622.3	1331.5
42	1863.0	1584.3
43	1972.3	1777.5
44	2082.2	1910.6
45	1747.3	1619.0

These data are plotted in Figures 10, 11, and 12. From these figures we find the following trends of expenses (before interest and taxes) in relation to sales.

For the period from 1902–1910, the trend is:

$$\text{Expenses} = \$60{,}000{,}000 + 60\% \text{ Sales}$$

For the period from 1920–1929 the trend is:

$$\text{Expenses} = \$33{,}000{,}000 + 80\% \text{ Sales}$$

For the period from 1939–1945, there are two trends. The trend from 1939–1942 is:

$$\text{Expenses} = -\$5{,}000{,}000 + 85\% \text{ Sales.}$$

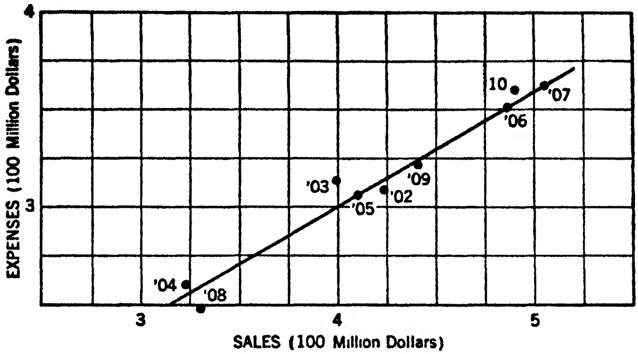

Figure 10. U. S. Steel Corp. Sales vs. Expenses before Interest and Taxes, 1902–1910

The period from 1943–1945 is too short to be evaluated with confidence.

In this example, we find three distinct trends of expenses (before interest and taxes) with sales, for the periods selected for illustration. We also find that each trend is straight but different in amount from the others.

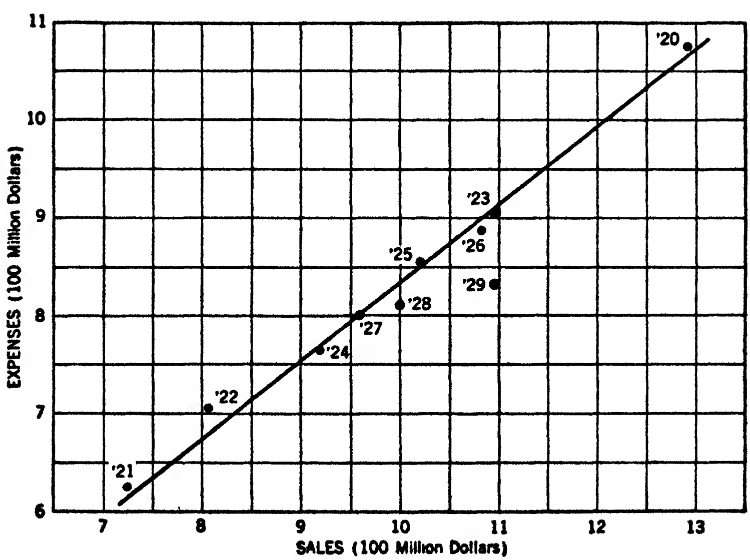

Figure 11. U. S. Steel Corp. Sales vs. Expenses before Interest and Taxes, 1920–1929

Finally, we see that if an additional technique is applied to this type of chart, it will be possible to visualize the historical trends of *profits* with sales over a span of several years. Thus trends in gross profits, operating profits or net profits, with variations in sales during different time periods or spans of years, may be visualized. This technique is demonstrated in Figure 13 through the use of the trend line developed in Figure 11.

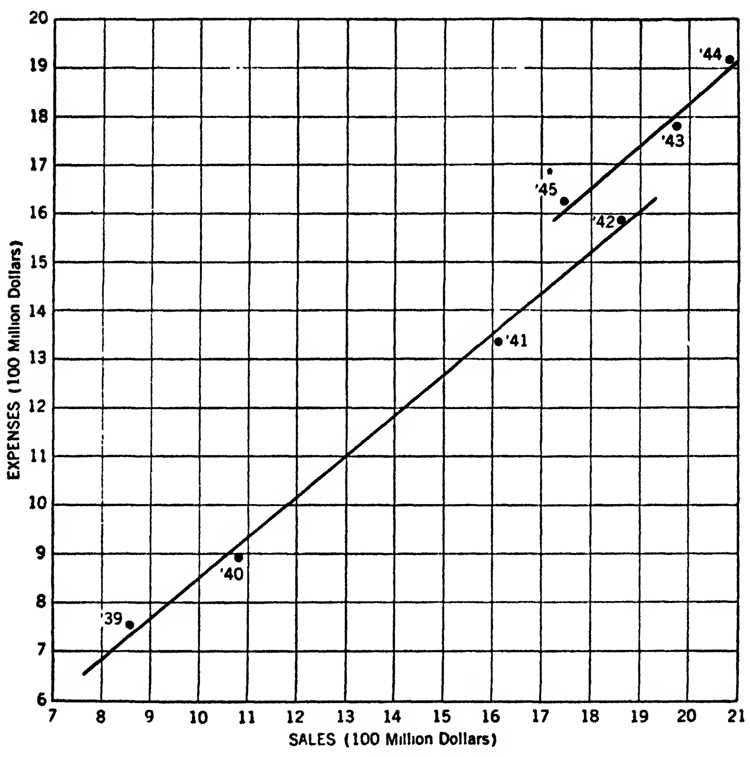

Figure 12. U. S. Steel Corp. Sales vs. Expenses before Interest and Taxes, 1939–1945

In Figure 13, the expense points and their trend line, as shown in Figure 11, are reproduced. If now a vertical be drawn through a given expense point, such as for 1921, when sales were 726 million dollars, and the length of this vertical be terminated at A (726 million dollars), it follows that the distance from the expense point to A will equal Sales-expenses = Profit. If again, for the year 1920, for example, a vertical is drawn through the expense point (1,075.4 million dollars)

and this vertical is terminated at a point B, which reads 1,290.6 millions of dollars (sales) in the vertical scale, it will appear that the distance from B to the expense point will equal the profit for that year. If A and B are joined, it will be observed that the line thus generated

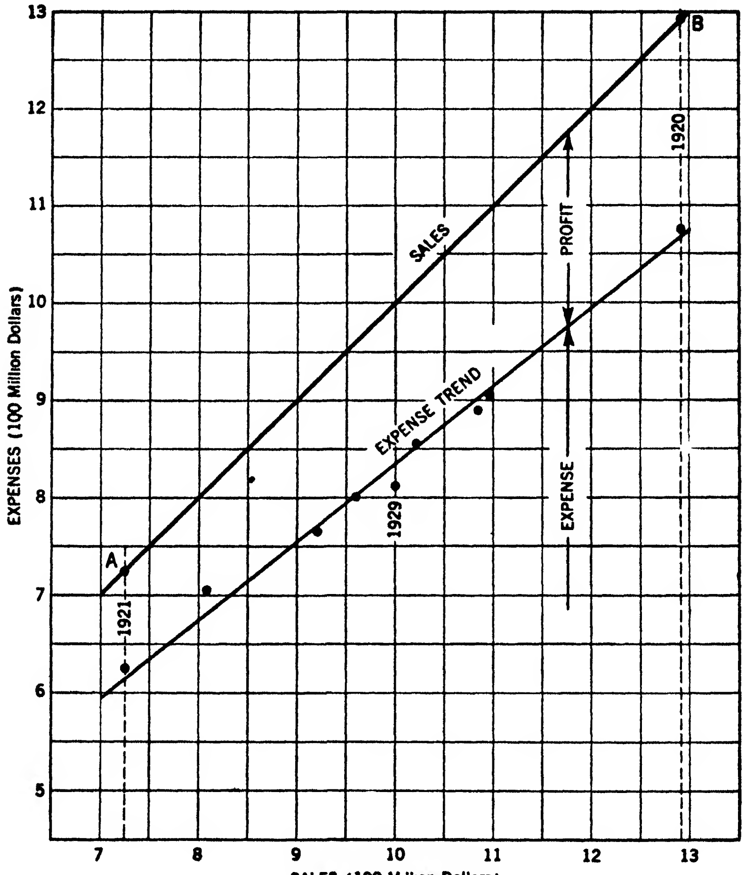

Figure 13. U. S. Steel Corp. Expense Trend, 1920–1929

will lie at an angle of 45° with the X- axis or the Y- axis, provided the same scales are used for the X- and Y- axes, and would, if extended, terminate at the origin of the axes. This additional technique permits the chart to reveal profit or loss as well as expenses and sales. Not only does it record the actual profit or loss for any given year but it also shows the variation of any particular profit or loss from the general trend, whence the name *Profit and Loss Chart.* Figure 13 is the Profit

and Loss Chart for the United States Steel Corporation for the years 1920 to 1929.

What general conclusions may be drawn from what has been observed so far about the relations between sales and expenses?

In the first place, the regularity of the sales and expense relationships so far observed suggests that expense is functionally related to sales. This appears to be the case for a whole industry as well as for an important unit in an industry chosen at random, from hundreds of industries and companies.

In Chapter V are shown the profit and loss charts of many well-known companies, all of which conform to the above pattern of relation between sales and expenses. Some companies experience new trends from time to time due to changes in the financial structure and methods of production as the business of the company expands. But the straight-line trends of the expenses either at higher or lower levels appear to persist for a span of years.

Why do the expenses show a straight-line relation to sales? Why should there be several trends, for any company, over a period of years?

In the first place, it should be noted that what have been plotted above are the *relations between expenses and sales,* and, just as expenses are influenced by the costs of materials, labor, and fixed charge, so also is the dollar value of sales influenced by the selling price of the quantities sold. Since, as a general rule, costs are reflected in prices, that is, prices are adjusted to costs (except under government controls as recently experienced in some instances), such adjustments appear to control also the trends of expenses to sales and hence maintain a consistency of pattern over a span of years.

In the second place, it should be noted that a company may be the same legal entity for a span of years, but at the same time it may, and usually does, experience changes in both its financial and physical structures. The United States Steel Corporation today is by no means anything like what it was in 1902, in physical equipment, financial structure, personnel, or in many other particulars. Also, the economic environment in which it operates, as characterized by wages and prices, is changing with time. The financial structures of companies, with their consequent effects on fixed charges, also change in time. Accordingly, with such changes, the expenses of operations per unit of output will stand at different levels over a period of time. When the United States Steel Corporation, for example, replaced its hand sheet

mills with cold rolled continuous mills, the labor cost per ton of output declined, since fewer men were needed for the same output.

But the important matter to note is that this type of analysis reflects the economic consequences of all these changes over a long span of years. The profit and loss statements for these years can not of themselves give any such perspective of the trends of expense with sales.

In the third place, the items of expense have different relationships in respect of sales, which relationships must be clearly defined if the general pattern of the relation between sales and expenses is to be dealt with intelligently.

It is necessary to inquire into such relationships *at a given time* in order to eliminate the effect of changes in environment and in the company's economic structure. If there is a functional relationship between sales and expenses over a span of years—and we have now seen that there is one—then, logically, there should also be such a relationship when the period considered becomes shorter than a year, say a month or a week.

II. THE BREAK-EVEN CHART

Let us now, therefore, inquire into the sales-expenses relationship at a given time. The first step in this analysis is to examine the expenses of operating a business, including manufacture, with respect of their functional relation to sales.

A. CLASSES OF EXPENSES

An analysis of the origin and nature of the items which make up the total expenses of a business at any particular time reveals that these items fall into two main groups, which are either *constant* (fixed plus regulated) or *variable* with respect of sales or output.

1. The *constant expenses* arise from three sources:

   a. Those occasioned by the possession of a business
   b. Those assessed for purposes of capital recovery of investment in fixed assets
   c. Those which arise in its operation.

The *costs to possess* are interest on mortgages, local taxes, insurance, and rent. These items of expense are based on the values of the assets possessed, and the rates of interest, insurance, and taxes applied to these values. The *costs of capital recovery* are determined by accounting for depreciation by methods to be considered in Part II. The

costs to possess and the charges for capital recovery (depreciation) together are frequently referred to as the fixed charges and are usually expressed on an annual basis. In financial circles, the term "fixed charges" refers to charges against bond and other investment certificates.

Thus, if the fixed assets of a business are $10,000,000 and the rates of insurance, taxes, and depreciation total 12 percent, and if there is a mortgage of $3,000,000 on the property bearing 5 percent interest the annual fixed charges are $1,350,000 and are due and payable * whether the factory is closed or is running to full capacity.

Another group of total constant expenses arises from the operations of the business at any particular time. These expenses are determined in part by the organic features of the business and also *in part* by executive policy concerning appropriations for such operations. For instance, the annual expenses of heating, lighting, part of power (connected load charge in the case of purchased power) and a portion of maintenance and repair of buildings and machinery are, for *any particular year,* in the life of a business fairly constant, and specific amounts of money may be budgeted annually for meeting such expenses. These expenses, moreover, are within limits controllable by management, since the amount of such expenses depends in part on how such services are organized and managed. These expenses are, to a degree, regulated from time to time by the executives of the business but for any year are budgeted as specific amounts, and are therefore considered as constant over a wide range of sales.

Another group of expenses, which is set up on an annual basis as a company anticipates its expenses for an approaching year or accounting period, consists of executive salaries and appropriations for advertising and other operating expenses which experience has shown are fairly constant, as sales vary over an appreciable range. A going concern at any particular time maintains a number of employees who are on annual salaries. The officers of the company, the department heads, and minor officials are in this class. The salaries of these employees are determined and regulated from time to time by executive action. But *for any particular year,* the total of such annual salaries is a determinable amount. If, later, the volume of business expands and the company prospers, salaries of officers may be raised and new salaried employees may be engaged. With a serious decline in sales, the number of salaried employees may be materially reduced.

* Depreciation is not currently payable but is incurred as an amortization of a prepaid item.

But at any time, the company's books will show a list of salaried employees together with their monthly or annual salaries and the total of such salaries does constitute an anticipated constant cost for the present condition of the business.

The executives of a business, in anticipation of a certain income from sales and from other sources, determine the annual appropriation for advertising and other promotional activities. Expenses so budgeted for a given year may be reduced in the following year if anticipated revenues are less, or may be increased if the prospects of increased sales seem to warrant. Accordingly, such expenses are constant at either higher or lower levels for an appreciable range of sales. Thus, expenses of the above kinds are regulated by executive action and are constant in time over a range of output. At any particular time, therefore, they are regulated constant expenses.

Finally, it is to be noted that the constant expenses which may be incurred by a business during any year are of two kinds

Fixed charges
- Cost to possess
- Cost of capital recovery

Regulated expenses
- Conditioned by the nature of the factory and its operations
- Determined largely by executive policy.

2. The *variable expenses* are those which increase or decrease directly with rise or fall in production and sales. The main items of such expenses in mechanical manufacture are material costs, labor costs, and commissions on sales. In the process industries, however, the labor costs, in some instances, do not vary greatly with variations in output. In mechanical manufacture the total *costs of materials* for a month or a year, both material entering into and becoming part of the product and materials consumed in operations, and the total *costs of labor* for a month or a year, both labor directly associated with productive operations and service labor, are found to vary in a manner closely approximating the rate of production. This is the case particularly because of flexibility in the use of equipment. A department having 100 machines of similar types will operate all these machines when sales demand is high and only, say, 50 machines with half the labor force when sales demand requires 50 percent utilization of capacity. In some cases, in which output varies with a given set-up of the machine because of the cost of the set-up, the labor cost will not vary directly with output. In the process industries, however, the same labor crew

must often be maintained to operate the various equipments even though output is only 50 percent of capacity. Accordingly, in the process industries it often happens that total labor cost is the same, or only slightly variable, for a wide range of output. It is also the case in the process industries that the total materials cost for a given output may vary with the "yield," according to the way the processes are operated.

With the exceptions of the situations noted, the costs of materials and labor for a given month or year vary with the output and, for a *given selling price*, with sales of the month or year.

B. CONSTANT AND VARIABLE EXPENSES IN RELATION TO SALES

How these classes of expenses are related to sales may be portrayed graphically, as in the following practical example.

Let us assume for purposes of illustration that a given company * estimates that for anticipated annual sales of $10,000,000 the following total expenses will be in accord (Table XIV):

TABLE XIV

A TYPICAL BUDGET OF EXPENSE AND PROFIT

1. Materials	$3,300,000
2. Labor	1,400,000
3. Other variable items	300,000
Total variable expenses	$5,000,000
4. Advertising and selling	2,300,000
5. Administration	500,000
6. Interest, insurance, depreciation, local taxes	400,000
7. Other constant items	300,000
Total constant expenses	3,500,000
Total all expenses	8,500,000
Profit from operations	1,500,000

Of the constant total expenses, we find.

Fixed charges	$ 400,000
Regulated expenses	3,100,000

It is also determined, as a matter of executive policy, that these annual constant expenses will be maintained for a sales decline to $9,000,000 and for a sales increase to $11,000,000. The variable expenses are

* Data for this example were derived from the averages of certain food products companies.

noted to be 50 percent of sales. If these data are plotted, the results are as shown in Figure 14.

The horizontal axis O-X represents annual sales to the scale; one unit equals $1,000,000 annual sales. The vertical axis O-Y represents annual expenses to the same scale as used for the axis O-X.

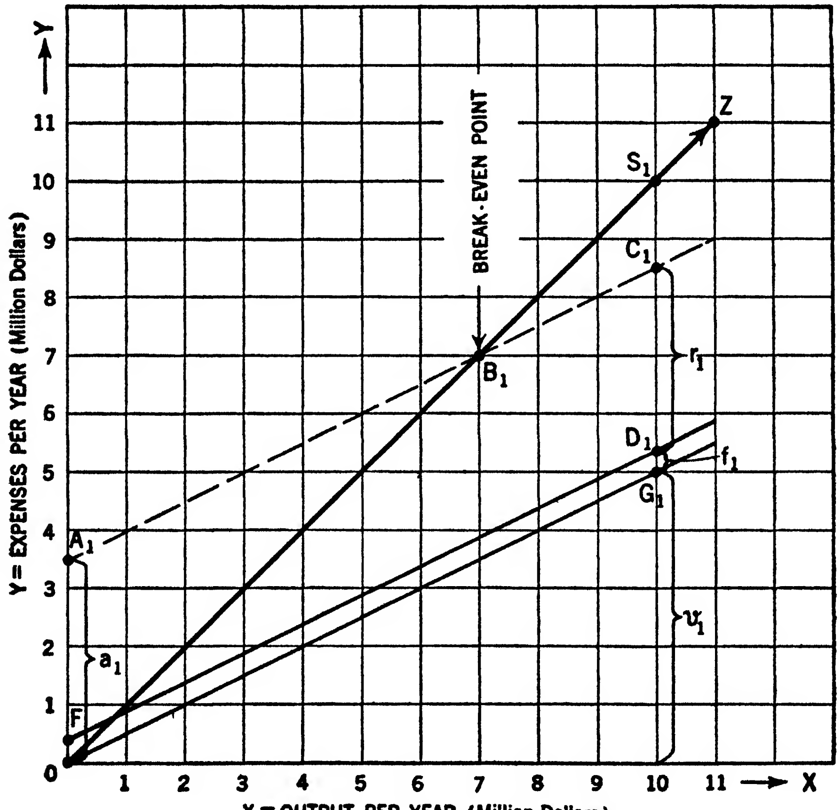

Figure 14. A Typical Break-even Chart

The point 10 on the X-axis locates sales of $10,000,000. At this point, erect a vertical line and at a distance v_1 from the base representing to scale the $5,000,000 total variable expense locate the point G_1. Then, draw a line from G_1 to the origin O. An ordinate to the line O-G_1 will measure the total variable expenses for any annual sales. For example, if annual sales should be $6,000,000, the total variable expenses should be $3,000,000, as the chart shows.

Above G locate the point D_1 at a distance f_1, which, to scale, represents the fixed charges of $400,000. Draw a line through D_1 parallel to O-G_1. This line cuts the Y-axis at F. The ordinate to this line will represent, for any annual sales, the amount of total variable expenses plus fixed charges for such sales. For example, for annual sales of $6,000,000 the sum of the total variable expenses and the fixed charges is $3,400,000. From the point D, measure upward the distance r_1, which to scale reads $3,100,000 (the regulated constant expenses), and locate the point C_1. Draw a line through C_1 and parallel to O-G_1 and where this line cuts the Y-axis, mark that point A_1. This line is drawn full between the verticals for annual sales of $11,000,000 and $9,000,000, because the ordinates to the full portion of the line are used to show what the total of all expenses (that is, the total variable expenses plus the fixed charges plus the total regulated expenses) should be for annual sales of any amount between $9,000,000 and $11,000,000. The remaining portion of the total expense here is drawn as a broken line to indicate what the total expense for sales less than $9,000,000 would be, if the regulated expenses were not adjusted when annual sales became less than $9,000,000. The line A_1-C_1 shows what the total expenses would be for any annual sales *on the basis of the present budget of expenses.* For example, for annual sales of $6,000,000 at the present budget of expenses the total of such expenses would be $6,500,000 and the business would run at a loss of $500,000. If annual sales should be $8,000,000, the chart shows that the total expense, if the present budget is maintained, would be $7,500,000, and the business would operate at a profit of $500,000. At annual sales of $7,000,000, the total expenses would be $7,000,000 and the business would break even. The amount of the annual profit and loss for any sales and the point in sales at which the business would break even may be shown on the chart by the simple expedient of drawing a 45 degree line through the origin, such as the line O-Z. Since the horizontal and vertical scales of the chart are equal, it appears that the ordinates to the 45 degree line from any point of the base are equal in length to the distance of this point from the origin O. For example, the ordinate at the point 10 of the base intersects the 45 degree line at S_1 or the total expense line and 0-10 = (10-S_1). The profit for sales of $10,000,000 is S_1-C_1 = $1,500,000. The loss for sales of $6,000,000 would be $500,000, according to the chart. Where the 45 degree line crosses the total expense line, the sales corresponding ($7,000,000 in this case), are the annual sales at which the

business is expected to break even, *provided that the budget of expenses for sales from $9,000,000 to $11,000,000 is not adjusted.*

But the prudent businessman, if he knows these facts about his business, will regulate his expenses when sales decline and adjust them to lower levels to avoid a loss. If, for example, it is indicated that sales will decline, the businessman will realize that he cannot afford any high constant expenses such as a_1, and therefore he must do something to reduce them. He must review those constant expenses which he can regulate to see what can be done about it. The results of such regulations are shown in Figure 15.

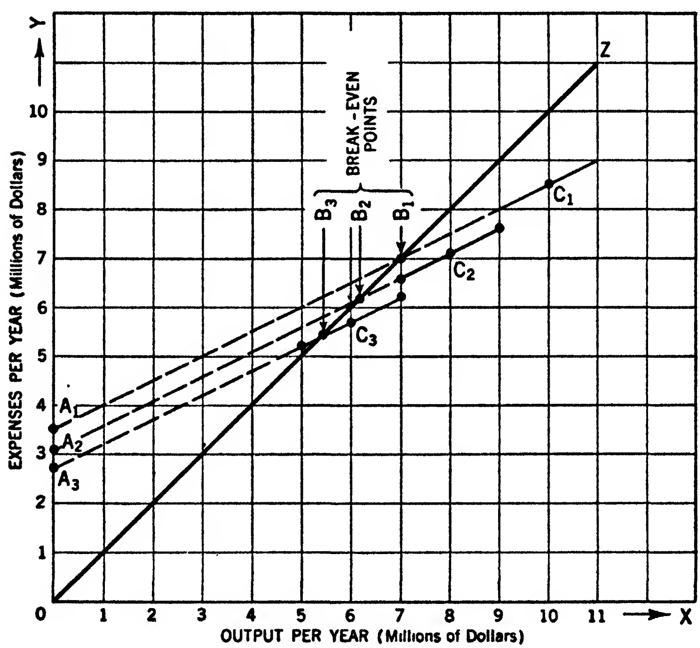

Figure 15. Lowering the Break-even Point by Adjusting the Regulated Expenses

Assume, in this case, that some salaried employees are laid off and other regulated expenses are lowered when annual sales decline below $9,000,000, and that this reduces the total expenses by $400,000. Assuming that this reduced total expense is designed to be maintained for annual sales from $9,000,000 to $7,000,000, then the total expense line *for this range of sales* would pass through C_2 as shown in Figure

15. If the same policy (of expense reduction) should be adopted for annual sales between \$7,000,000 and \$5,000,000, then the total expense trend for this range of sales would be defined by the line through C_3 in Figure 15. In practical operations, quite obviously, these lines will really merge into each other because executive decisions are necessarily made in some cases in anticipation of events. Accordingly, as Figure 15 illustrates, by adjusting the regulated expenses for sales between \$7,000,000 and \$9,000,000, the break-even point is lowered from

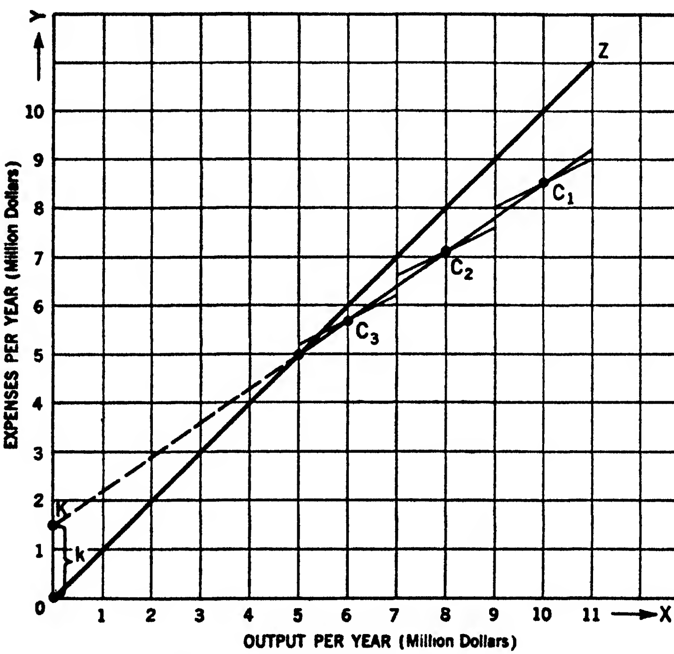

Figure 16. Adjustment of Regulated Expenses

B_1 to B_2 and the total constant expenses are reduced from O-A_1 to O-A_2. Likewise, if further adjustments of the regulated expenses are made when it is anticipated that sales will be between \$5,000,000 and \$7,000,000, the break-even point is again lowered to B_3 and the total constant expenses become O-A_3. As noted above, however, these adjustments may be made more gradually with the result that instead of having a series of steps in the total expenses, there results a trend in total expenses along a line connecting the points C_2 and C_3. The midpoints, C_1, C_2, C_3, of the three total expense trends, as above de-

fined, are found to lie on a straight line, as shown in Figure 16, and this line represents the central trend of total expenses with sales when the policy of adjustment of the regulated expenses is as above described. When the line of central trend is extended until it cuts the Y-axis the intersection K becomes merely a point of orientation of the line of the central trend of expenses and *does not define,* by its distance from the origin k, the constant total expenses of the business at any time.

With the above policy of adjustment of the regulated expenses there are three constant total costs, one for annual sales from $9,000,000 to $11,000,000, another for annual sales from $7,000,000 to $9,000,000 and yet another for annual sales from $5,000,000 to $7,000,000. For each of these total costs there exists a different break-even point, as shown in Figure 15.

The point of orientation of the probable line of central trend of total expenses, as sales vary over a wide range, depend on the policy of adjusting the regulated expenses. We will now review the three charts of Figures 14, 15 and 16 to learn their full meaning.

In the first place, it must be noted that the above relationship of expenses to sales is for *sales at constant selling price.* The effect of a change in selling price of the products sold on the *relationship* between expenses and sales will be developed subsequently. In the next place, it is to be noted that all items of expense are based on definitely budgeted expenses for salaries and other items, and for current materials costs and wages rates. The above pattern of relationship is therefore based on the above conditions of unit prices and unit costs. With such a *norm* based on current conditions it is not only possible to show the probabilities of profit or loss for varying sales income under current conditions of operation but also to show how profit and loss will depart from this norm upon changes in prices and costs of materials and wages.

We will first review Figure 14, which establishes the norm of profit and loss at current prices and costs, and at the current expense budget. Here we find that the point A_1, determined as previously described, does show the amount of the total constant expenses of the business under operating conditions (from $9,000,000 to $11,000,000 annual sales). The break-even point under these operating conditions can also be predicted by the chart. In this case, it is $7,000,000. For sales below this amount there will be a loss if the operating budget is not adjusted for lower sales.

It will be noted that the slope of the total expense line A_1-C_1 is of the form

$$\text{Total expense} = y = a + bx$$

where $a =$ the total constant expenses
$b =$ the ratio of the total variable expenses to sales

and $x =$ sales

In this case $a = \$3{,}500{,}000$

and $b = 0.50$

Thus the total expenses which the business will incur for any sales x is found to be

$$y = \$3{,}500{,}000 + 0.50\,x$$

It is also to be noted that the 45° line of sales income is of the form

$$y = x$$

When the sales income x is equal to the total expenses y the business is just breaking even. Accordingly, the business will break even when

$$x = y$$

or

$$x = a + bx$$

that is, when

$$x\ (\text{sales}) = \frac{a}{1 - b}$$

In this case

$$x = \frac{\$3{,}500{,}000}{1 - 0.50} = \$7{,}000{,}000$$

This value is identical with that determined by the chart Figure 14. Also, the amount of profit or loss to be anticipated for any sales (x) under operating conditions for \$9,000,000 to \$11,000,000 annual sales is:

$$P = x - y$$

or

$$P = x - (a + bx) = x(1 - b) - a$$

For sales of \$10,000,000, it is found that

$$P = \$10{,}000{,}000\ (1 - 0.50) - \$3{,}500{,}000 = \$1{,}500{,}000$$

and for sales of \$5,000,000 under current operating conditions

$$P = \$5{,}000{,}000\ (1 - 0.50) - \$3{,}500{,}000 = -\,\$1{,}000{,}000$$

If, as shown in Figure 15, the regulated expenses are reduced to \$3,100,000 in the anticipation of a decline in sales from \$9,000,000 to \$7,000,000, then the business will break even at sales of

$$x = \frac{\$3{,}100{,}000}{1 - 0.50} = \$6{,}200{,}000$$

A further reduction of regulated expenses to \$2,700,000 in anticipation of sales from \$7,000,000 to \$5,000,000 will result in a break-even point of

$$x = \frac{\$2{,}700{,}000}{1 - 0.50} = \$5{,}400{,}000$$

Since the reductions in regulated expenses in anticipation of declining sales are not usually made abruptly but rather more gradually, the net effect on the *central trend* of total expenses is more nearly as shown in Figure 16, and is along the line C_1-C_2-C_3. How may the equation of the line C_1-C_2-C_3 be found and how is it to be interpreted? By extending the line to the Y-axis, a point of orientation K is found. The distance k of the point K above the origin is \$1,500,000. *This does not imply that the constant expenses of the business for a range of sales from \$5,000,000 to \$11,000,000 are this sum.* Let this amount O-K be given the symbol k. The slope of the line is found by observation from the chart and is

$$\frac{8{,}500{,}000 - 1{,}500{,}000}{10{,}000{,}000} = 0.70$$

Let this be given the symbol v. The equation of the line is therefore (expense = e)

$$e = k + vx = \$1{,}500{,}000 + 0.70\,x$$

Accordingly, as a company while maintaining its selling price adjusts its regulated expenses in anticipation of a decline or an increase in sales and such declines or increases eventuate a line of central trend drawn through the experienced expense points will result in values of k and v as above defined which do not disclose the constant expenses nor the trend of variable expenses as they are budgeted at any particular period in the history of the business. As shown in Figure 15, for example, when sales varied between \$9,000,000 and \$11,000,000, the total constant expenses during that period (expenses which did not vary with sales) were O-A = \$3,500,000; for sales from \$7,000,000 to \$9,000,000, those expenses which did not vary with

sales were \$3,000,000; and for sales from \$5,000,000 to \$7,000,000, the company reduced the expenses which were not affected by sales output to \$2,500,000. But the historical pattern of the trend of total expenses with sales over these three periods, as shown in Figure 16, was such that the trend line of total expenses when extended cuts the Y-axis at K and thus defined the point of orientation of the expense line. The quantity O-A_3 of Figure 15, minus the fixed expenses O-F of Figure 14, shows the level to which the regulated expenses were reduced to obtain the break-even point B_3 as shown in Figure 15.

The historic pattern of expense trend must not be confused with the break-even chart at any particular time in the life of a business.

For purpose of clarification, the historic pattern of sales-expense trend experience by a company *over a span of years* (*the Profit and Loss Chart*) will be expressed by the equation,

$$e = k + vx$$

where

e = expense
k = the ordinate of the point of orientation of the trend line
v = the slope of the trend line
x = sales

The sales-expense trend of a company *at any particular time* (*the Break-Even Chart*) will be expressed by the equation,

$$y = a + bx$$

where

y = expense
a = constant total cost
b = ratio of variable total costs to sales

The historic pattern of expenses (materials, labor, factory expense, cost of sales, selling and administration expenses) in relation to sales (the profit and loss chart), particularly for the past several years, should be part of the equipment of every executive office. Indeed, every commercial bank extending credit to any business and every investment banker purchasing the securities of any corporation should have such a graph for every business with which they deal.

The reason is, that such a chart shows at a glance the ability or inability of the management to adjust its expenses and prices and to maintain adequate profit margins during the growth of the business.

With plant expansion and increasing fixed charges, and with increasing labor and materials costs, the ability of management is severely challenged with respect of maintaining profits over a wide range of sales. Accordingly, the trends of expense in relation to sales, when showing a consistent regularity, generally indicate a capable management.

Departure from established trends, however, may be due to various causes, such as sudden increases in basic costs which can not be compensated for by price adjustments, or to other causes beyond the control of management. It may also be due to additional fixed charges from new plant enlargements, the results of which are not yet balanced by increased sales. Thus the profit and loss chart, properly interpreted, indicates the significant results of past management and the potentialities of the future.

III. THE BREAK-EVEN CHART—IN TERMS OF THE QUANTITY OF GOODS PRODUCED

Break-even charts are of two main types: those in which the X-axis is laid off in terms of dollars of sales, which has just been considered, and those in which the X-axis is laid off in terms of physical quantities of output, which will now be explained. The former is applicable to such companies as manufacture a variety of products. Both the former and the latter are applicable to companies which manufacture a single type of product, such as sugar, steel, lumber, etc., the outputs of which are measurable in physical units. Even those companies manufacturing a variety of products may use the physical unit type of break-even chart for each kind of product.

Both types of charts, the one based on dollar units and the one based on physical units, may be constructed for a business as a whole, for departments of the business and for each product manufactured.

One of the writers was put in charge of a plant producing a product sold by the pound. The first thing that needed to be done was to determine the break-even chart for current operations. No manager can control a business without a clear picture of the operating characteristics of that which is to be controlled. The annual profit and loss statement of the business, expressed in round numbers, was as in Table XV.

The percentage of profit on sales (2.08) was too small. But the statement gives no indication of the constant and variable expenses. To find these classes of expense, each item of the expenses was carefully analyzed and the following summary of results determined (Table XVI).

TABLE XV

PROFIT AND LOSS STATEMENT

——— Inc.

Net sales		$2,400,000
Cost of goods sold		
Materials	$300,000	
Labor	500,000	
Factory expense	800,000	1,600,000
Gross profit		800,000
Administration expense	200,000	
Sales expense	550,000	750,000
Profit from operations		$ 50,000

TABLE XVI

ANALYSIS OF EXPENSES

Item	Total	Constant	Variable
Material	$ 300,000	——	$ 300,000
Labor	500,000	——	500,000
Factory expense	800,000	500,000	300,000
Administration expense	200,000	200,000	——
Selling expense	550,000	300,000	250,000
Totals	$2,350,000	$1,000,000	$1,350,000

The annual output of product was 800,000 lbs. and the average selling price was 30¢ per lb.

From these data the chart shown in Figure 17 was constructed as follows:

Lay out the base of the chart to the scale 1 unit = 10,000 lb. Lay out the vertical scale at the left of the chart to 1 unit = $100,000. At 8, at the base of the chart, erect a vertical line. On this line locate successively the points M, L, F_1, and S_1 to represent the materials expense M = $300,000; the labor plus materials expenses L = $500,-000 + $300,000; the labor plus materials plus the variable portion of factory expense F_1 = $300,000 + $500,000 + $300,000; and S_1 = the variable portion of the selling expense plus material labor and the variable portion of the factory expense—a total of $1,350,000. Lines through these points to the origin show how each item and the total of variable expenses will change with the rate of annual production. The points F_2, A, and S_2, representing the summations of the con-

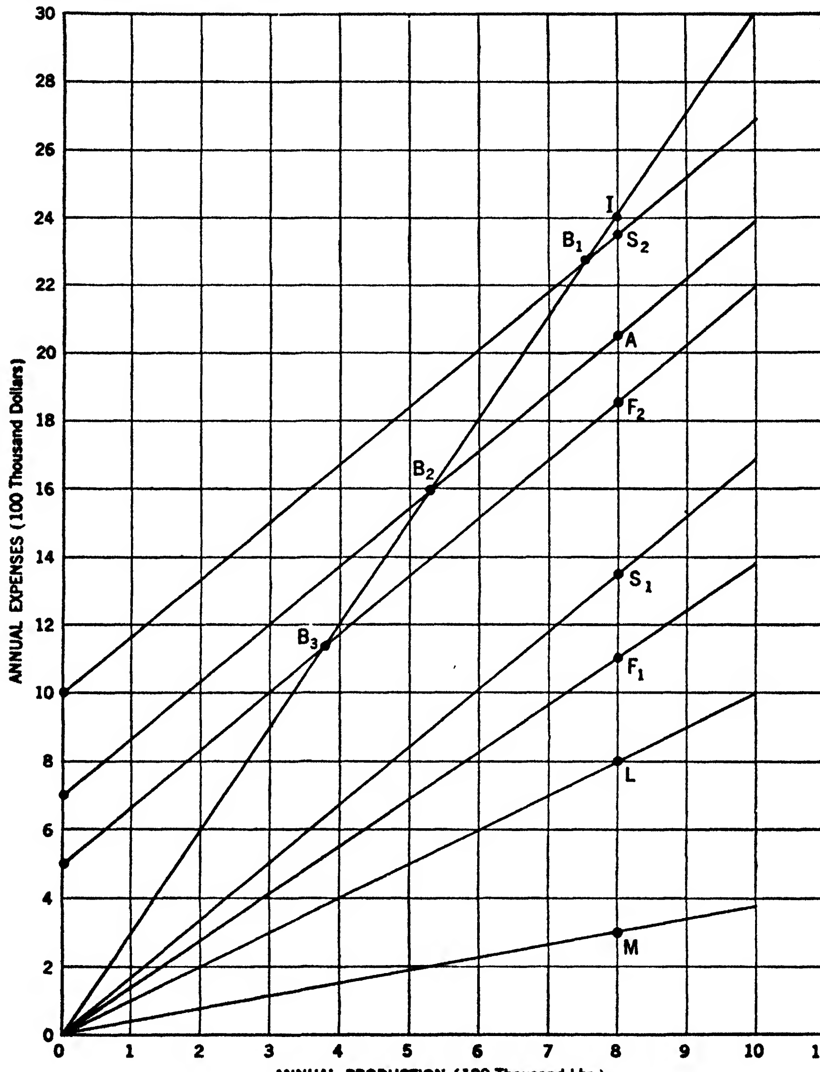

Figure 17. The Break-even Chart for Quantity of Output

stant portion of factory expenses, the administrative expense and the constant portion of selling expense are located as shown, and lines through these points and parallel to O-S_1 are drawn. Locate I at a distance of $2,400,000 along the vertical, and draw the line O-I.

The intersection of O-I with the line through F_2 shows that the

business will break even before administrative and the constant and selling expenses at B_3 = 385,000 lbs. annual output. At B_2 = 535,000 lbs. annual output, the business will break even before absorbing the constant portion of the selling expense. At B_1 = 760,000 lbs. annual production, all expenses are absorbed. But a 5% price drop would

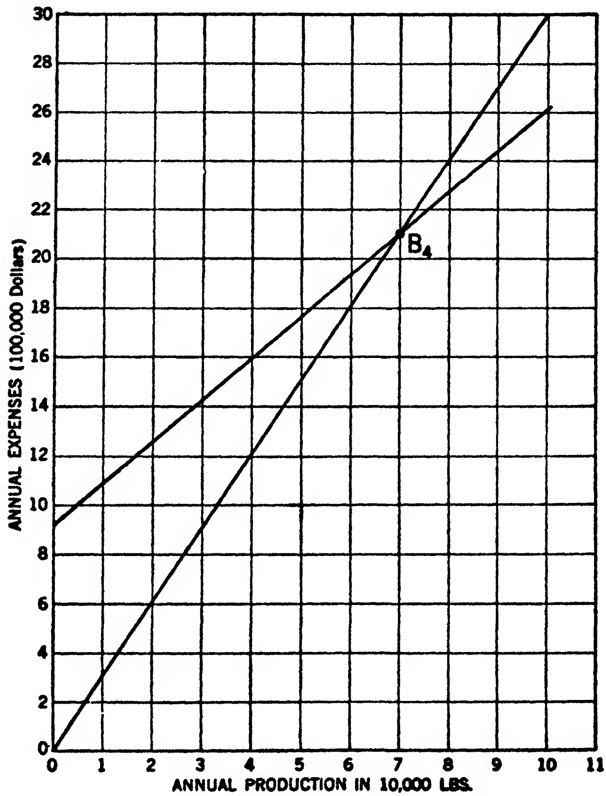

Figure 18. The Break-even Chart of the Same Business after Expense Reduction

wipe out profits. It appears that for immediate results, improvement in profits could be made by attacking the two largest items of constant expenses, the regulated portion of the selling expenses, and the regulated portion of the factory expenses. It was found that the overhead in both manufacture and selling had grown out of proportion to effective results. An intensive study of both these divisions of operation revealed the fact that the manufacturing overhead through

reorganization and reduction of some salaries and personnel could be reduced by $50,000. The promotional expenses of selling and the expenses allowed sales representatives could be reduced by $30,000. This resulted in a total reduction of $80,000.

The new break-even chart, Figure 18, shows that the break-even point has been lowered to 700,000 pounds annual output *at present selling prices* of 30¢ per pound.

This accomplishment gave the new management a better margin to work on while tackling other and more difficult problems of reducing expenses through revamping manufacturing operations. The profit potential at present sales was raised from $50,000 per year to $160,000 per year, an increase of 220 percent. In a few minutes of chart construction, the important results of reorganization are revealed at a glance where many hours' calculation would otherwise be required, *and even then no visualization of results obtained.*

In the next chapter we will show how the break-even chart analysis is used for answering some of the important problems which management faces today.

There has been some discussion of the break-even chart lately in the daily press. For instance, the *New York Times,* October 3, 1948, expressed itself on the matter as follows:

> . . . the 'break-even chart,' which is the invention of Dr. Walter Rautenstrauch of Columbia University . . . discloses the economic characteristics of the whole business process, from the investment of capital to the sale of the final product.

In the same article, Mr. Clinton W. Bennett, President of the National Association of Cost Accountants, was quoted as saying:

> . . . the break-even chart may prove one of the most valuable tools in management's kit.

V

CHARTS OF BUSINESSES AND INDUSTRIES

PROFIT AND LOSS CHARTS can be easily prepared for any American business by using the data generally available to the public in the annual reports to the stockholders, the reports of the Securities and Exchange Commission, and Moody's and Poor's *Manuals*, available in most libraries. The consolidated data for whole industries are published by such agencies as the Federal Trade Commission. The data for constructing break-even charts, on the contrary, are of a more confidential character. Only high-ranking executives normally have access to the accounts which show the break-down of expenses in their constant (fixed and regulated) and variable components. In the following pages, the profit and loss charts of various businesses, and of whole industries, are prepared from data which is generally available through the sources that are noted above.

The data for the break-even charts have been provided from confidential sources, whose origin must necessarily remain anonymous.

I. PROFIT AND LOSS CHARTS

We have prepared several hundred profit and loss charts of many companies and whole industries, selected examples of which are given below. In general, the war period from 1941 to 1944, and the reconversion period following the war, resulted in many changes in sales-expense patterns, compared to prewar years. This was particularly the case with the heavy metal industries. In food and clothing there were few changes in methods of manufacture. But the government forms of contract during the war period brought about changes in accounting procedure which made it impossible in many cases to make valid comparisons between postwar and prewar periods in regard to many kinds of expense items. Accordingly, while the records of fact as to sales and the different classes of expense in many cases were properly certified to by accounting authorities, there were many new facts, such as renegotiation provisions and operations in government-owned plants, which called for some changes in accounting procedures over those of prewar years.

For these reasons it will be found that the profit and loss charts of many companies, during and immediately following the war years, show marked departures from previous patterns. It will also be found, as one examines the published annual statements of corporations, that it is not always possible to learn the gross profit * and the operating profit * of many of them.

For example, the General Electric Company reported its Sales and Net Income for the year 1946 as in Table XVII.

It will be noted that in the statement the cost of goods sold, the administrative expense, and the selling expense are all lumped together in Item (2). Accordingly, it is not possible from this statement to determine the gross profit of the company. It will also be noted that depreciation and amortization are not included in the cost of goods sold as is the practice with some other companies. Item (4), Income or loss from sales, corresponds to the operating profit which, in this case, is an operating loss. As a manufacturer, the company in 1946 was not successful. Yet it had a net income for the year, Item (10), of $43,039,589. How did it derive this income? Its investments in affiliated companies and in other securities were $12,042,880, against which was a charge of $1,219,067. It also received $33,000,000 from the Federal Government in tax returns and contract adjustments against which was a charge of $250,000 for Federal taxes in current

* See Chapter X for precise definitions of these terms.

TABLE XVII

GENERAL ELECTRIC COMPANY

Statement of Sales and Net Income
For the Year Ending Dec. 31, 1946

1. Net sales billed	$679,078,216
2. Costs, expenses, and other charges, except those shown separately below	659,894,709
3. Depreciation and amortization of plant and equipment	19,717,731
	679,612,440
4. Income or loss from sales	– 534,224
5. Income from other sources	
Interest and dividends (affiliated companies)	10,071,650
Other sundry revenues	1,971,230
	12,042,880
Less interest and other financial charges	– 1,219,067
	10,823,813
6. Total income before charges or credits shown below	10,289,589
Charges or credit for	
7. Federal taxes	– 250,000
8. Claim of Federal tax refund on prior years	24,000,000
9. Postwar adjustments	9,000,000
	32,750,000
10. Net income for year	43,039,589

income. This statement shows, among other things, how important the item of "other income" may be in the statement of company operations. The officers of the company, of course, have more detailed statements of operations than those published for distribution to the stockholders.

The following charts, prepared from the data of the published statements of the corporations, are, and necessarily must be, given in terms of the accounting classifications of expenses which these companies use. Accordingly, the "profit and loss" shown in each case is the profit and loss *before* whatever other expenses that are not accounted for. In a number of cases the profit and loss trend *before Federal taxes* is given for the reason that such expenses are not under the control of the company and their inclusion distorts the picture of the inherent economic characteristics of the business. In some cases, there are shown only certain classes of expense in relation to sales, to illustrate the fact that in many cases the expenses of different levels

(cost of manufacture of goods sold, for example) show specific trends over either short- or long-term periods.

We will examine the data of individual companies in different lines of endeavor and also of some whole industries.

A. INDIVIDUAL COMPANIES

1. *The Pet Milk Company*

On March 4, 1948, the *New York Times* published the record of the above company from 1929 to 1946, in which the following Sales and Expenses are found (Table XVIII).

TABLE XVIII

PET MILK COMPANY (A)

Date	Sales	Expenses before Depreciation Federal Income Tax and Special Reserves
	(Millions of Dollars)	
1929	26.89	25.63
30	24.42	22.89
31	20.99	19.84
32	15.33	14.66
33	15.68	14.44
34	19.42	17.99
35	23.09	21.47
36	25.10	23.27
37	29.70	28.13
38	28.55	26.73
39	29.71	27.58
40	34.90	32.25
41	52.07	47.84
42	66.73	61.88
43	76.34	71.59
44	95.83	89.71
45	114.77	107.02
46	113.33	109.91

When these expenses are plotted against sales we find that they closely average 97 percent of sales for the entire period of 17 years as sales varied from a low of 15.33 million dollars to a high of 114.77 million dollars. During this period, however, the company has been

adding to its properties and enlarging its productive capacity. Yet the trend of these expenses to sales has been consistent during this entire period. The above expenses, as is noted, are before Federal income taxes, Depreciation and Special Reserves. The *total* expenses include these items and when plotted against sales show the profit which is adjusted to surplus. The total expenses, including all charges (Federal taxes, also) and the net profit for this company for the years 1933-1946 were as in Table XIX.

TABLE XIX

PET MILK COMPANY (B)

Year	Total Expenses	Profits Adjusted to Surplus
	(Millions of Dollars)	
1933	15.22	.468
34	18.78	.647
35	22.31	.787
36	24.19	.911
37	29.00	.699
38	27.65	.901
39	28.58	1.129
40	33.66	1.240
41	50.59	1.496
42	65.28	1.452
43	75.10	1.246
44	94.80	1.039
45	113.34	1.432
46	111.62	1.713

The Total Expenses when plotted against Sales gives the results shown in Figure 19. The trend of Total Expenses is found to be:

$$\text{Average total expenses} = -\$500{,}000 + 98\%\ \text{Sales}$$

This means that *on the average*, this company earned in net profits, after all charges, including Federal income taxes:

$$\text{Annual profit} = 2\%\ \text{Sales} + \$500{,}000.$$

Comparison with Other Milk Companies. It is sometimes desirable to know how companies in the same industry compare with one another in the above particulars. Four such companies are selected for comparison as to their own annual total expense trends.

Pet Milk Company
Average annual total expense = — $500,000 + 98% sales
The Borden Company
Average annual total expense = — $500,000 + 89.5% sales
National Dairy Products
Average annual total expense = $8,000,000 + 90.5% sales
The Beatrice Creamery
Average annual total expense = $2,000,000 + 93% sales
Carnation Company
Average annual total expense = $1,500,000 + 90.5% sales

During 1939, these companies had the following annual sales:

Pet Milk Company	$ 29,700,000
Borden Company	350,000,000
National Dairy Products	400,000,000
The Beatrice Creamery	90,000,000
Carnation Company	60,000,000

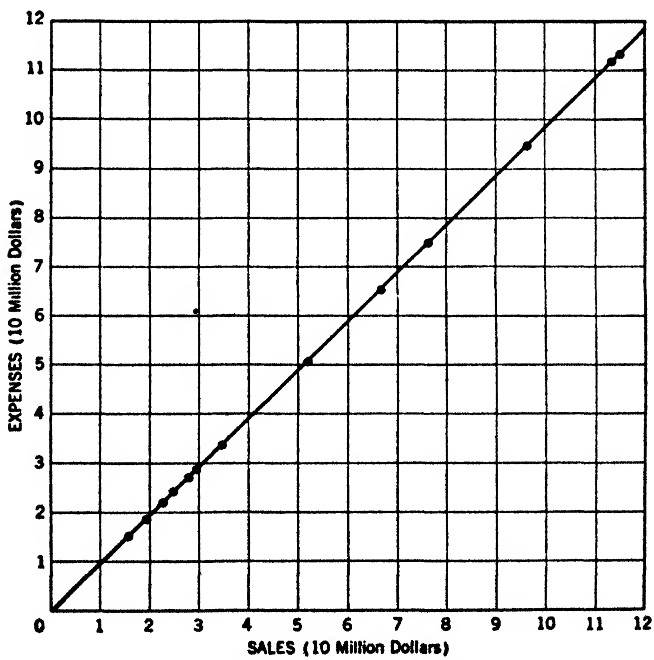

Figure 19. Pet Milk Co. Sales vs. Total Expenses, 1933–1946

2. *The Allis-Chalmers Company*

During the period from 1933, the depth of the depression, to 1947, including the war years, this company reports (Moody's *Industrials*) the following annual sales, costs of sales, and general, administrative, and selling expenses (Table XX).

TABLE XX

ALLIS-CHALMERS COMPANY

Year	Sales	Costs of Sales	General, Administrative, and Selling Expense
	(Millions of Dollars)		
1933	13.25	9.95	5.84
34	20.33	13.81	6.79
35	38.78	29.37	6.20
36	58.94	43.75	8.53
37	87.31	64.20	11.60
38	77.51	61.15	11.53
39	74.30	56.30	11.45
40	87.05	65.05	13.05
41	121.93	91.90	14.08
42	195.9	152.2	14.10
43	295.9	243.3	14.40
44	379.4	304.2	16.60
45	270.3	244.8	18.20
46	93.4	100.4	19.20
47	211.9	179.9	23.60

Plotting the cost of sales against sales, as shown in Figure 20, clearly reveals the straight-line pattern of the cost of sales from 1933 to 1944 and the resulting gross profit. The straight line trend from 1933 to 1944, during which annual sales expanded from 13.25 million dollars to 379.4 million dollars, is followed by a rapid recession in sales after the war to 93.4 million dollars in 1946 and a rise to 211.9 million dollars in 1947. During 1945 to 1947, the cost of sales departed from the trend of prior years. The equation of the cost of sales line (1933-1944) is — \$2,000,000 + 78% of sales. The administrative, selling, and general expense of the firm are also plotted in Figure 20, from which it is found that during the war years these expenses were fairly uniform but increased substantially after the war period.

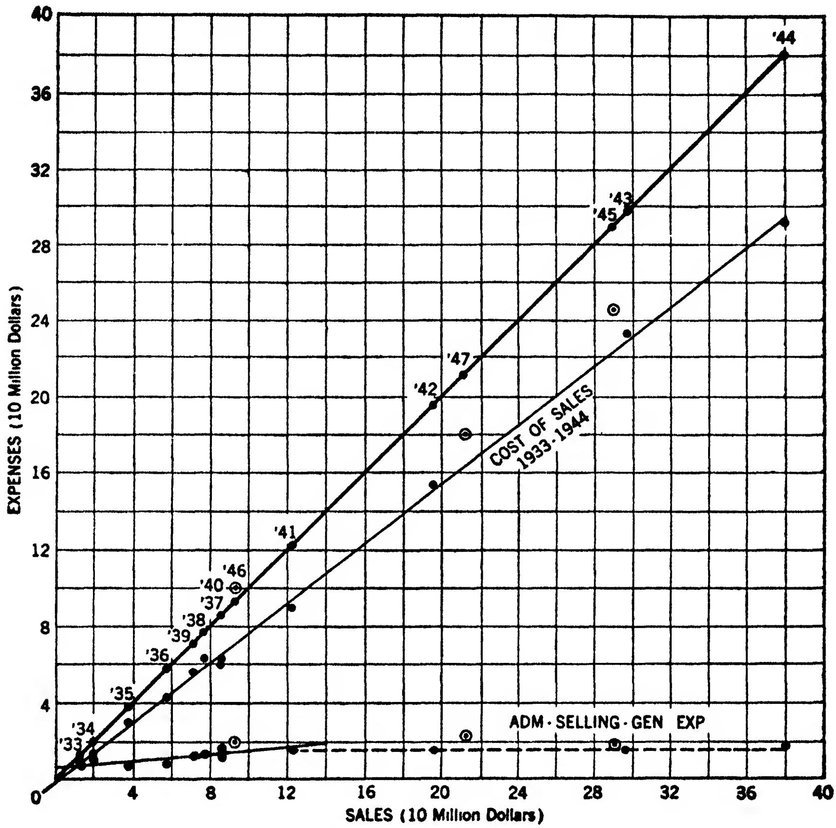

Figure 20. Allis-Chalmers, 1933–1947

3. *The National Lead Company*

The record of the company for the years 1934 to 1947 for annual sales, cost of sales, and general, administrative, and selling expenses is shown in Table XXI, page 113.

These data are plotted in Figure 21, for cost of sales and for total operating expenses (cost of sales, selling, general, and administrative expenses). The cost of sales follows a straight line trend for the entire period from 1934 to 1947 with only the years 1937, 1941, and 1945 showing any substantial departure from the trend. The equation of the trend of cost of sales is:

$$\text{Cost of sales} = -\$500{,}000 + 84.2\%\ \text{sales}$$

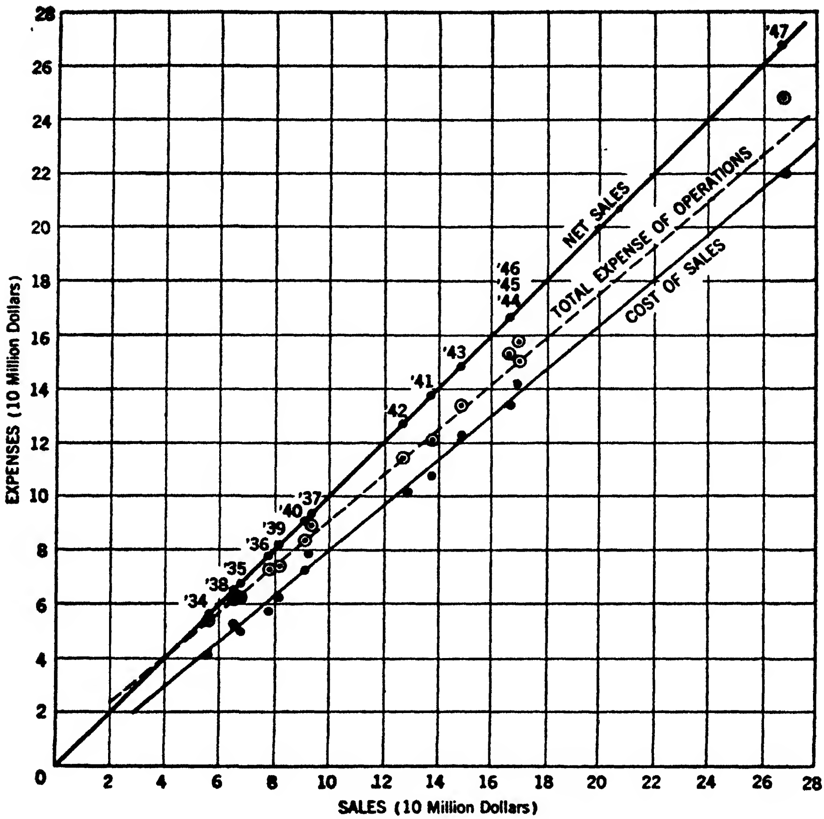

Figure 21. National Lead Co., 1934–1947

When the total operating expenses are compared to sales, it is found that there is a fairly good straight-line trend from 1934 to 1944. Due to the substantial increases in the selling, general, and administrative expenses in 1945, 1946, and 1947, the total operating expenses for these years depart from the trend of the prior years. The equation of trend of total operating expenses from 1934 to 1944 is:

$$\text{Total operating expenses} = \$600{,}000 + 85\%\ \text{sales}$$

After declaring the expenses of operations, the company reports other income from dividends received and interest on securities, and income from other sources, so that the operating profit plus other income results in a net profit somewhat greater than the profits from operations.

It is generally more helpful in visualizing a company's operations to

plot the expenses *before* other income and other expense, and then plot the points only for the expenses *after* net other income. This was not done in this case because the illustration is too small to show these points with clarity.

TABLE XXI

NATIONAL LEAD COMPANY

Year	Sales	Costs of Sales	General, Administrative, and Selling Expense
		(*Millions of Dollars*)	
1934	56.35	41.62	11.18
35	66.56	49.67	12.62
36	78.76	57.85	15.23
37	91.95	78.16	10.11
38	65.23	51.48	9.71
39	80.90	61.99	11.66
40	90.69	71.08	10.98
41	139.1	108.4	12.6
42	127.6	101.1	12.6
43	148.6	121.2	12.5
44	166.1	134.7	14.9
45	167.5	140.9	16.1
46	167.4	134.1	18.7
47	268.0	220.7	26.2

4. *The Dow Chemical Company*

The operations of this company for the years 1938 to 1947 are reported in Moody's *Industrials* as in Table XXII.

TABLE XXII

DOW CHEMICAL COMPANY

Year	Sales	Cost of Goods Sold	Total Operating Expenses
		(*Millions of Dollars*)	
1938	21.71	15.83	17.34
39	23.45	16.84	18.70
40	37.74	27.35	30.17
41	46.91	33.18	36.87
42	78.38	56.43	60.27
43	105.43	76.96	81.43
44	120.43	94.62	100.48
45	124.57	95.52	102.44
46	101.81	85.04	93.05
47	130.43	——	110.59

These data are plotted in Figure 22, from which it will be noted that both the cost of goods sold and the total operating expenses follow very definite straight-line trends in relation to sales for the period from 1938 to 1943. After 1943, during the war period and after the war, both the cost of goods sold and the total operating expenses in relation to sales depart from their respective prior trends. While the chart shows that these expenses for the years 1944-1947 have increased *with respect to sales,* does this mean that these expenses have increased in relation to physical volume of output? It may or it may

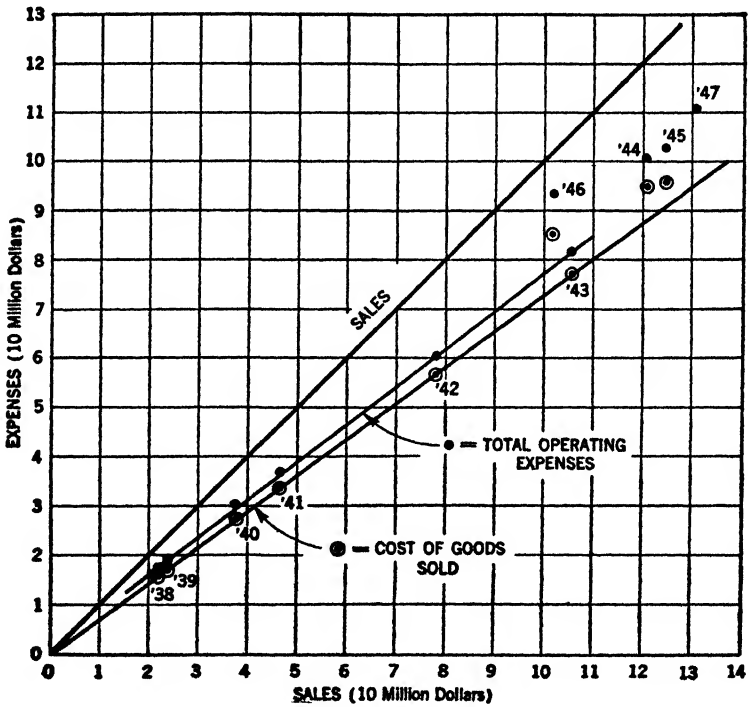

Figure 22. Dow Chemical Co., 1938–1947

not. We have no information on unit selling prices and therefore can not answer the question.

If unit selling prices had been reduced, the effect shown in the chart may be accounted for. Or it may indicate both that selling prices had been reduced and that expenses per physical volume of output may have increased. Both causes may have been operating. This is a good example of how expense points may lie outside of a prior trend,

due to either price change or expense change or both. The real causes must be learned from more detailed reports of operations, and which are not available in the usual published financial reports.

5. *The Monsanto Chemical Company and Subsidiary Companies*

This company, in its 45th annual report to stockholders, issued in 1946, gives a record of its operations from 1937 to 1946, from which the particulars in Table XXIII are taken.

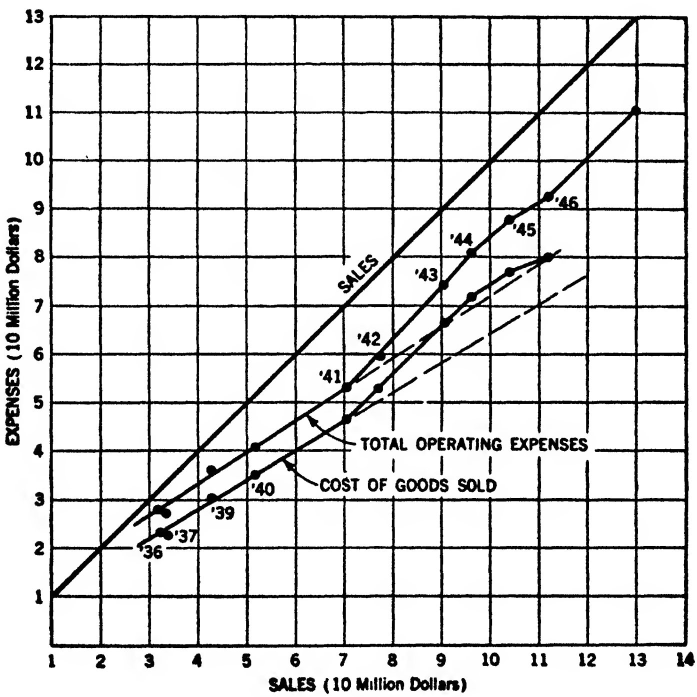

Figure 23. Monsanto Chemical Co., 1937–1946

These data are plotted in Figure 23, from which the following observations may be made. From 1937 to 1941, both the costs of goods sold and the expenses of operations follow a straight-line trend in relation to net sales. If this trend had continued for the next five years, the result would be as indicated by the continuing broken lines. Both gross profits and operating profits were greatly reduced *relative to net sales* during the period from 1942 to 1946 as compared to the

TABLE XXIII

MONSANTO CHEMICAL COMPANY

Year	Net Sales	Cost of Goods Sold	Expense of * Operation
		(Millions of Dollars)	
1937	33.20	23.00	27.15
38	31.93	23.50	27.92
39	42.98	30.12	35.70
40	51.11	34.88	40.72
41	70.27	46.31	52.64
42	77.05	52.68	59.56
43	90.45	66.33	74.05
44	96.10	71.93	80.79
45	104.35	76.99	87.69
46	111.42	79.97	92.12

* Cost of goods sold plus selling, administration, and research expenses.

prior trend. The Dow Chemical Company, on the other hand, not only more than doubled its sales from 1941 to 1943, but it also maintained its profit trend in relation to sales of prior years. Both the Dow Chemical Company and the Monsanto Chemical Company experienced increased expenses in relation to sales during the period from 1944 to 1946.

6. *The Lehigh Portland Cement Company*

The report on this company is found in Moody's *Financial Manuals*, and for the years 1938 to 1946 the following results are recorded (Table XXIV).

TABLE XXIV

LEHIGH PORTLAND CEMENT COMPANY

Year	Net Sales	Manufacturing Expenses	Total Operating Expenses and Fixed Charges
		(Millions of Dollars)	
1938	12.07	7.44	11.61
39	14.80	8.36	12.95
40	16.92	9.68	15.10
41	22.37	12.65	18.57
42	25.30	14.12	19.80
43	17.30	10.36	15.80
44	13.37	8.98	13.18
45	14.65	9.57	14.08
46	25.83	16.31	22.99

Upon plotting the manufacturing expenses against net sales as shown in Figure 24, it is found that they fall into two groups. Those which fall along the trend line M_1 are for the years 1938 to 1943 while those

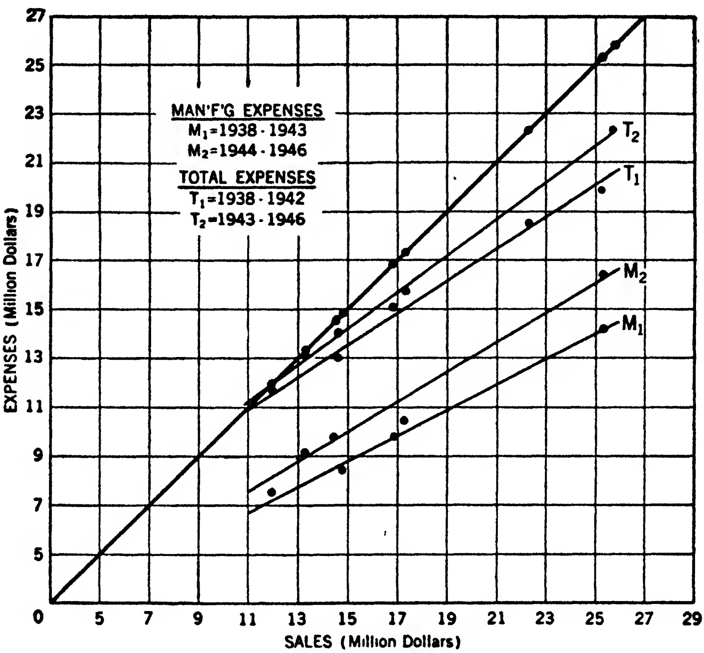

Figure 24. Lehigh Portland Cement Co. Manufacturing Expenses and Total Expenses

which fall along the trend line M_2 are for the years 1944 to 1946. The total operating expenses and fixed charges for the period from 1938 to 1942 fall along the trend line T_1, while for the period from 1943 to 1946 they fall along the trend line T_2.

7. The Equitable Office Building Corporation

This corporation is reported in Moody's *Financial Manuals* as having the annual incomes and expenses for the years from 1931 to 1947 shown in Table XXV.

The relation between operating income and total expenses are as plotted in Figure 25. The total expenses are found to follow a fairly definite trend as shown. The equation of this trend is

$$\text{Total expenses} = \$2{,}400{,}000 + 24.5\% \text{ of operating income}$$

TABLE XXV

EQUITABLE OFFICE BUILDING CORPORATION

Year	Operating Income	Total Expenses
	(Millions of Dollars)	
1931	6.39	3.98
32	6.06	3.93
33	5.25	3.81
34	4.68	3.47
35	3.86	3.25
37	3.53	3.26
39	3.15	3.16
41	2.98	3.06
47	3.45	3.24

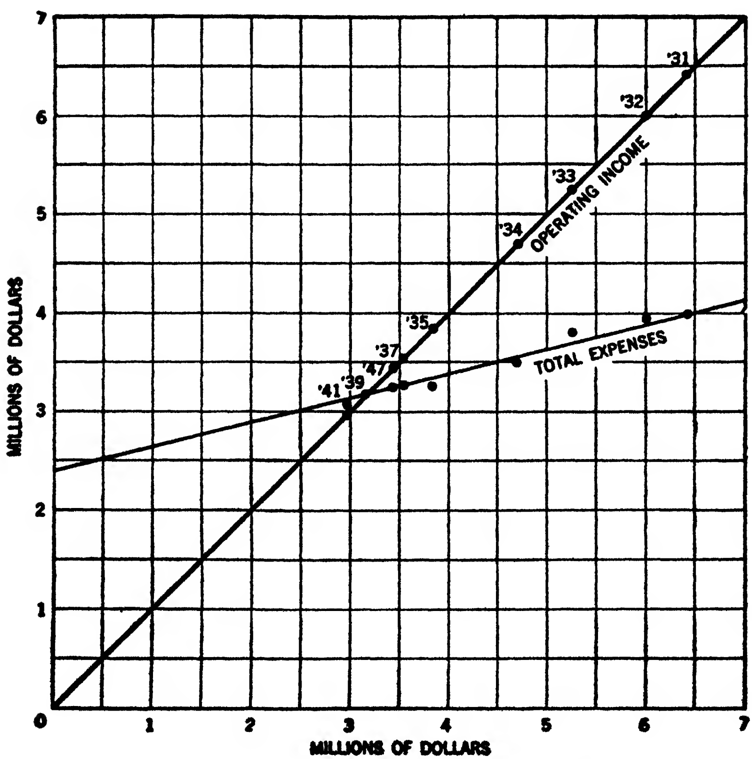

Figure 25. Equitable Office Building Corp., 1931–1947

8. *Montgomery Ward and Company*

The net sales and total expenses of this company from 1934 to 1947, for alternate years, are reported as follows in Table XXVI.

TABLE XXVI

MONTGOMERY WARD AND COMPANY

Year	Net Sales	Total Expenses
	(Millions of Dollars)	
1934	187.63	185.49
36	293.04	280.01
38	414.09	393.38
40	474.88	447.48
42	632.70	604.40
44	595.93	575.56
46	654.77	632.20
47	974.25	928.96

These data are plotted in Figure 26 and show that the expenses follow a straight-line trend.

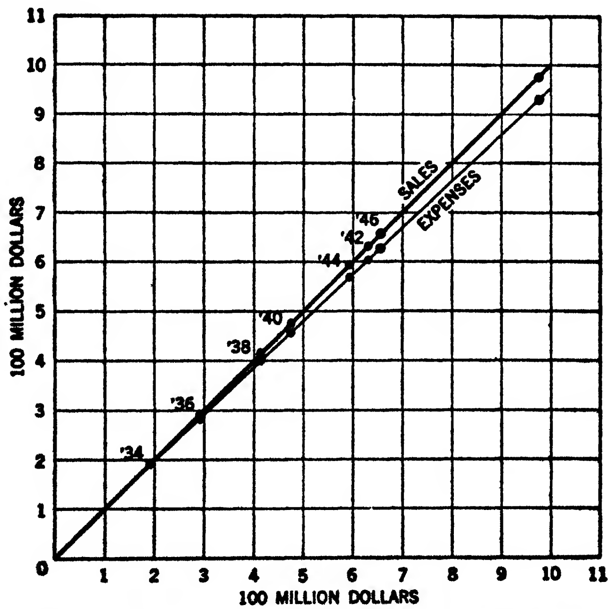

Figure 26. Montgomery Ward & Co., 1934–1947

9. The General Motors Corporation

The operations of this company from 1922 to 1945 show two very different types of trend of total operating expenses to sales. During the period from 1922 to 1935, total operating expenses followed the trend shown in Figure 27, while during the period from 1935 to 1945

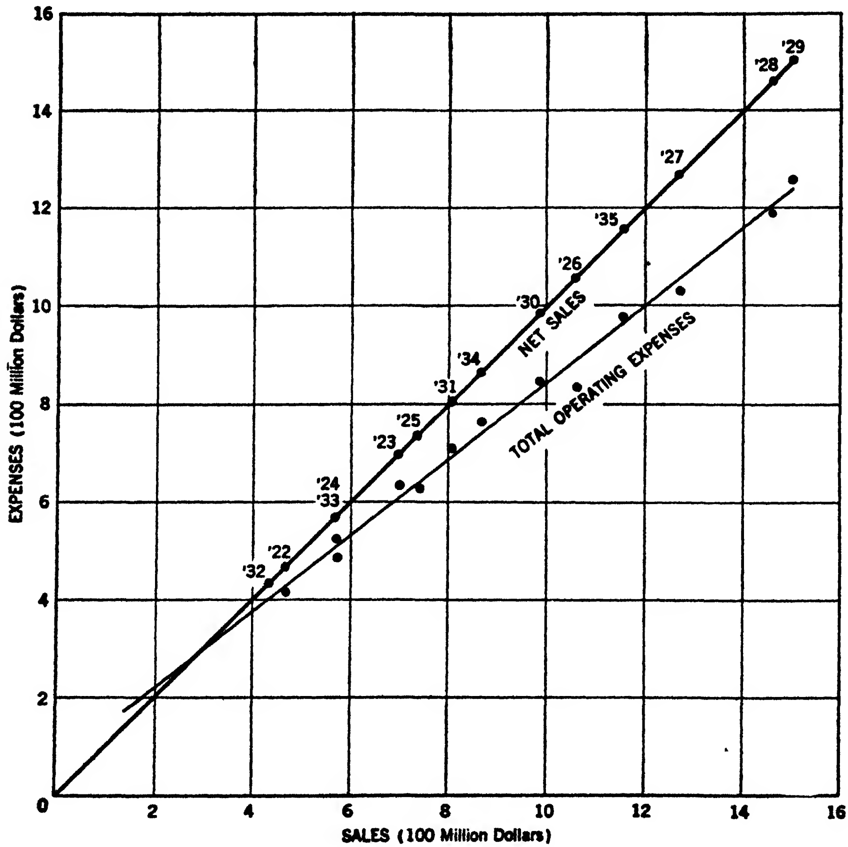

Figure 27. General Motors Corp., 1922–1935

the trend was as shown in Figure 28. The broken line, marked "Expense Trend 1922-1935," Figure 28, shows how the two trends compare. The data used for plotting these charts are those reported in Poor's *Financial Manuals*, and are as shown in Table XXVII.

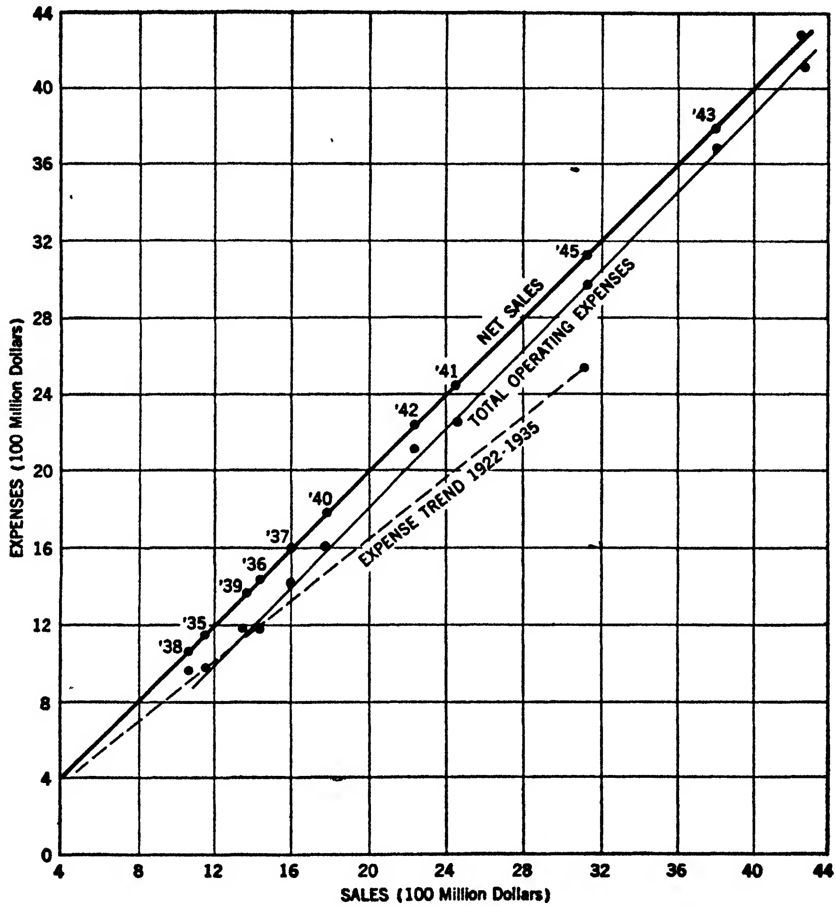

Figure 28. General Motors Corp., 1935–1945

B. WHOLE INDUSTRIES

The data on operations of whole industries, such as contract construction and manufacture, have been compiled by various agencies. The United States Department of Commerce, in its *Survey of Current Business* and in its supplements thereto, publishes data on the incomes and expenses of the industries of the United States. Its most recent publication on this matter was in July, 1947. From these publications, and from other sources, we have prepared the following profit and loss charts of important industries.

TABLE XXVII

GENERAL MOTORS CORPORATION

Year	Net Sales	Total Operating * Expenses
	(100 Millions of Dollars)	
1922	4.63	4.11
23	6.98	6.35
24	5.68	5.22
25	7.34	6.27
26	10.58	8.31
27	12.69	10.30
28	14.59	11.86
29	15.04	12.57
30	9.83	8.40
31	8.08	7.12
32	4.32	4.32
33	5.69	4.84
34	8.62	7.61
35	11.55	9.73
36	14.39	11.81
37	16.06	14.00
38	10.66	9.60
39	13.76	11.85
40	17.94	15.94
41	24.36	22.22
42	22.50	21.12
43	37.96	36.38
44	42.62	40.82
45	31.27	29.56

* Manufacturing, selling, administrative, taxes, incidentals, depreciation, United States and foreign income taxes.

1. The Mining Industry

The profit and loss chart for this industry for the years 1932 to 1946 is shown in Figure 29. The expenses plotted are before interest charges, and therefore the vertical distances between the sales line and the line of expense trend shows for any year the estimated annual amounts available for interest and dividends.

The equation of the line of expense trend for 1932 to 1941 is

$$\text{Total expenses} = \$600{,}000{,}000 + 66\%\ \text{Sales}$$

From this equation it follows that the annual sum available for disbursement to capital as dividends and interest for the years from 1932 to 1941 approximated

$$\text{Interest and profit} = 34\%\ \text{Sales} - \$600{,}000{,}000.$$

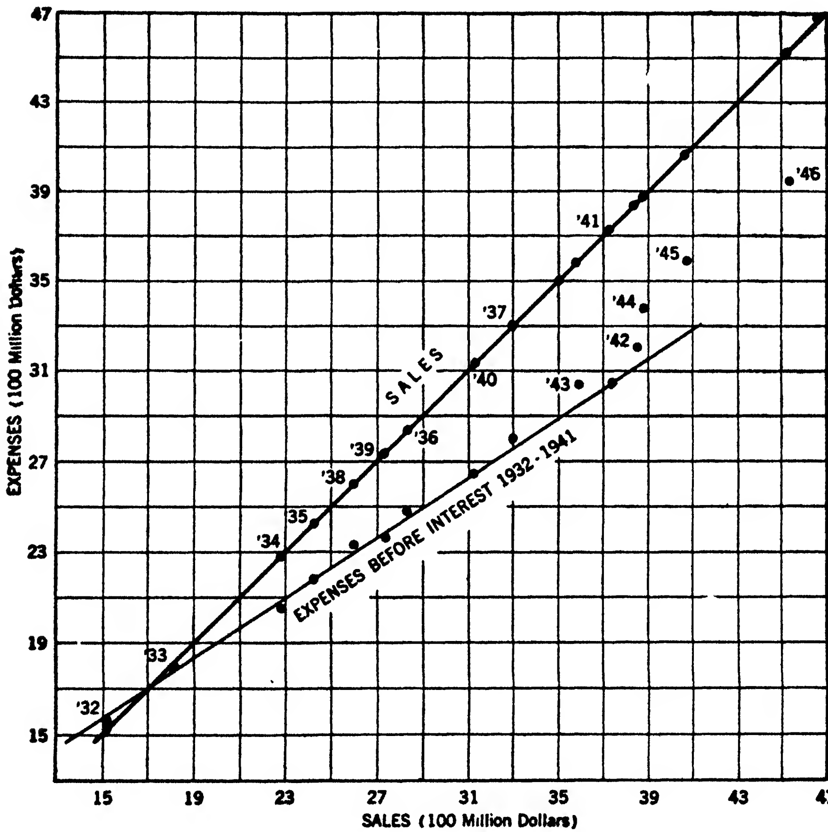

Figure 29. The Mining Industry, U. S. A., 1932–1946

From 1942 to 1946, due to higher taxes and other causes, the industry did not follow the trend in expenses of the years 1932 to 1941.

The data from which the chart (Figure 29) is constructed are as follows in Table XXVIII.

TABLE XXVIII

MINING INDUSTRY

Year	Sales	Total Expenses before Interest	Profit and Interest
		(Millions of Dollars)	
1932	1,511	1,564	53
33	1,817	1,795	22
34	2,293	2,073	220
35	2,413	2,180	233
36	2,836	2,482	354
37	3,295	2,792	503
38	2,594	2,340	254
39	2,731	2,379	352
40	3,114	2,642	472
41	3,723	3,079	644
42	3,865	3,232	633
43	3,579	3,044	535
44	3,863	3,338	525
45	4,071	3,588	483
46	4,519	3,946	573

TABLE XXIX

CONTRACT CONSTRUCTION INDUSTRY

Year	Sales	Total Expenses before Interest	Profit and Interest
		(Millions of Dollars)	
1929	2,802	2,665	137
30	2,789	2,679	120
31	2,035	2,010	25
32	1,290	1,355	− 65
33	962	998	− 36
34	1,110	1,136	− 26
35	1,334	1,331	3
36	1,793	1,762	31
37	2,208	2,162	46
38	1,926	1,898	28
39	2,208	2,174	34
40	2,473	2,401	72
41	3,452	3,260	192
42	4,643	4,326	317
43	4,219	3,982	237
44	3,101	2,974	127
45	3,287	3,134	150
46	4,898	4,598	300

2. *The Contract Construction Industry*

The record of this industry in the matter of sales and expenses for the period from 1929 to 1947 is shown in Figure 30. The profit before interest for all of these years was consistently approximate to

$$\text{Interest and profit} = 8.7\% \text{ Sales} - \$130{,}000{,}000$$

The small percentage of profit on sales in the industry is not at all comparable to the earnings on the capital invested. The contractor has much less invested per dollar annual sales than does the manufacturer, the miner, or the public utility owner. The data from which Figure 30 is constructed are as in Table XXIX.

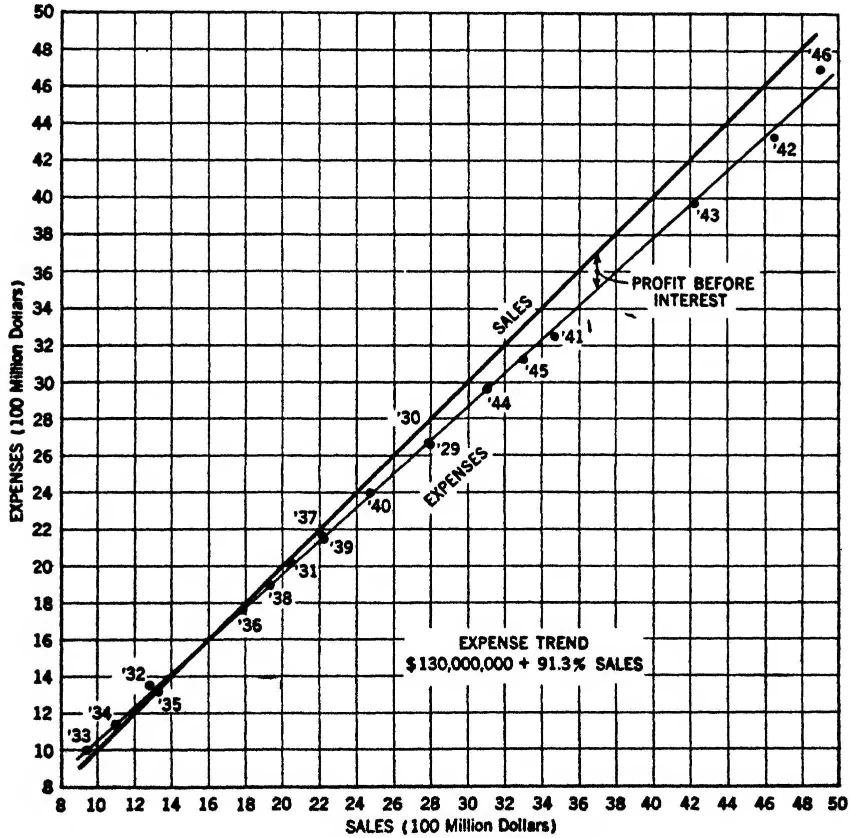

Figure 30. Pattern of Sales and Expenses in Contract Construction, U. S. A., 1929–1946

3. *The Manufacturing Industries*

The manufacturing industries expanded enormously in dollar value during and after the war period. In 1940, their annual sales were over 65 billions of dollars and in 1944 they were over 148 billions of dollars. In 1946 it was 125.9 billions of dollars. Interestingly enough, the trend of total expenses before excess profits and income taxes during the war period did not depart very much from the expense trend during the peacetime years from 1933 to 1940.

In Figure 31 is shown the trend of expenses before excess profits and income taxes with sales for the years 1933 to 1940. The equation of this trend is

$$\text{Expenses} = 3.6\text{B} + 87\% \text{ sales}$$

where B = billions of dollars.

In Figure 32 is shown the relation of expenses before excess profits and income tax deductions to sales for the period from 1942 to 1946. The expenses are shown by the circled dots. For purposes of com-

TABLE XXX

MANUFACTURING INDUSTRIES

Year	Sales	Total Expenses after Interest before Income and Profit Taxes	Total Expenses after Interest after Income and Profit Taxes
		(Billions of Dollars)	
1933	34.3	33.4	33.7
34	40.1	38.7	39.0
35	46.7	44.5	45.0
36	55.9	52.3	53.0
37	61.4	57.7	58.5
38	50.0	48.4	48.8
39	57.1	53.4	54.2
40	65.7	60.1	61.9
41	92.0	80.8	86.3
42	116.2	103.5	111.0
43	142.0	127.7	136.4
44	148.5	134.8	143.2
45	137.8	127.1	133.3
46	125.9	115.0	119.6

parison, the expense trend for the period 1933 to 1940 is extended for this period, from which it is seen that the average of the years 1942 and 1943 is on the trend line while the expenses for the years 1944,

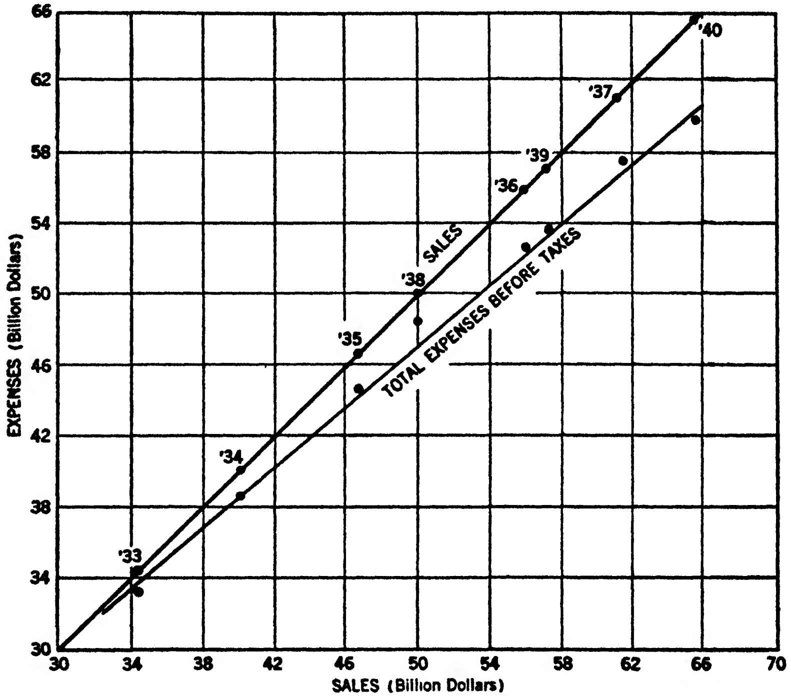

Figure 31. The Manufacturing Industries Expense Trend, 1933–1940

1945, and 1946 are slightly above the trend line. During 1947, the annual sales for the first, second, and third quarters, according to the Federal Trade Commission reports, total about 109.5 billions, which is at the annual rate of approximately 146 billions of dollars. The net income before taxes for the three-quarter period is reported to be 12.4 billions of dollars, or at an annual rate of 16.5 billions of dollars. When these annual data are projected on the chart, the expense for 1947 is located at the point marked X, which is slightly under the expense trend line and is a close fit. The data used in plotting Figures 31 and 32 are as in Table XXX.

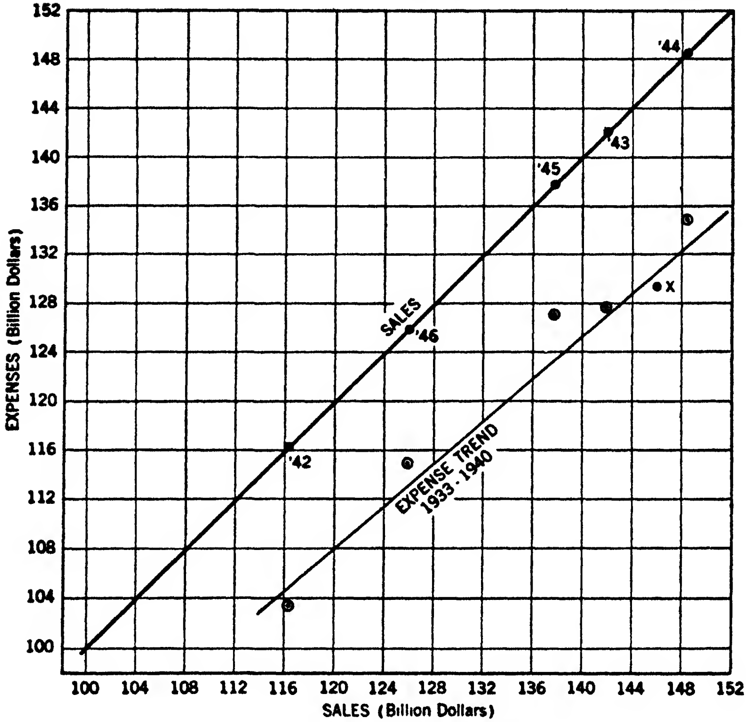

Figure 32. The Manufacturing Industries Expenses vs. Sales, U. S. A., 1942–1946

4. The Electric Utility Industries

The Edison Electric Institute issues annually very complete detailed data on the revenues and expenses of the electric utility industries. Table XXXI shows the operating revenue, the expenses before taxes (operating revenue deductions before taxes), the total expenses, and the net income for the years from 1933 to 1946.

These data are plotted in Figure 33, from which it will be noted that the operating expenses before taxes for the period from 1933 to 1943 followed a definite straight-line trend. The equation of this trend is

$$\begin{array}{c}\text{Operating expense}\\ \text{before taxes}\end{array} = -\,1.5\text{B} + 56\%\ \text{Sales}$$

where B = billions of dollars.

The total expenses (after taxes) follow a straight-line trend from 1933 to 1940, after which date the Federal income and excess profits taxes become very much greater, bending the total expense line sharply upward.

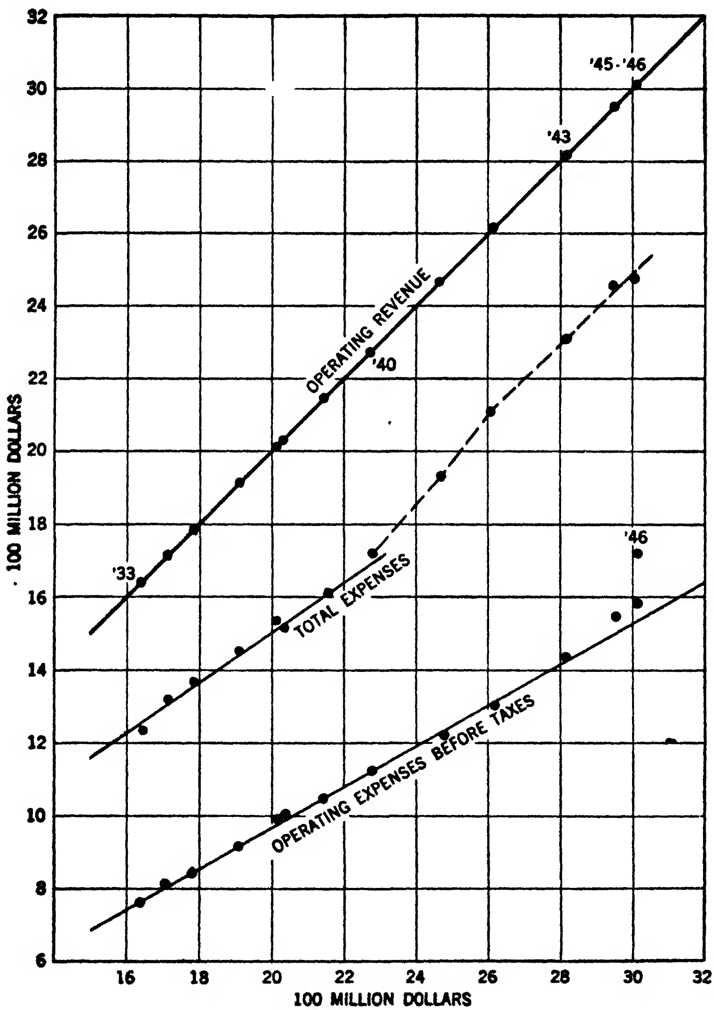

Figure 33. Electric Utility Companies, U. S. A., 1933–1946

TABLE XXXI

ELECTRIC UTILITY INDUSTRIES

Year	Operating Revenues	Operating Revenues Deductions before Taxes	Total Expenses	Net Income
		(*Millions of Dollars*)		
1933	1,640	766	1,236	404
34	1,710	812	1,319	391
35	1,785	853	1,365	420
36	1,911	918	1,451	460
37	2,031	997	1,522	509
38	2,018	988	1,533	485
39	2,148	1,047	1,609	539
40	2,277	1,123	1,720	557
41	2,467	1,226	1,930	537
42	2,609	1,305	2,110	499
43	2,816	1,434	2,304	512
44	2,955	1,544	2,438	517
45	3,012	1,581	2,467	545
46	3,121	1,718	2,463	658

II. BREAK-EVEN CHARTS

As stated previously, the break-even chart is derived from the confidential data of a company and can not be constructed from the data of a company's published statements. Such confidential data are made available to us in our professional practice but we can not use them without the permission of the company, and then only without stating the source of the data. A well-known company, which we will designate The XYZ Company has let us use its data for the following illustration of the relation between the several annual break-even charts of the company and the profit and loss chart of the company over the same period.

This company, for many years, has followed the practice of computing its break-even point each year by the usual laborious accounting procedure. This requires each year the service of three or four computers working many hours. The following table gives the results of their computations of the break-even points for the years 1938 to 1947. The graphic method, when applied as illustrated in Figure 34 for the year 1938 gave the break-even point as well as a clear picture of the whole trend of expenses with sales in a very few minutes. The graphic method has now been adopted by this company.

The data computed by the company were as in Table XXXII.

TABLE XXXII

THE XYZ COMPANY

Schedule of Net Sales and Expenses

1938–1947

Year	Break-Even Point *	Net Sales to Trade	*Operating Expenses and Cost of Goods Sold* Total	Constant	Variable
1938	$12,913,911	$15,226,066	$14,019,590	$ 6,738,608	$ 7,280,982
39	13,960,717	17,130,619	15,517,845	7,103,074	8,414,771
40	14,603,717	18,460,978	16,517,463	7,358,083	9,159,380
41	16,172,047	21,265,247	18,720,357	8,081,010	10,639,347
42	19,732,569	29,900,347	25,184,698	9,151,768	16,032,930
43	22,638,923	36,905,230	30,841,545	9,622,221	21,219,324
44	28,418,513	40,965,311	35,565,101	12,231,044	23,334,057
45	27,182,197	44,871,999	35,732,036	14,044,769	21,687,267
46	32,948,713	44,697,252	38,681,441	16,871,059	21,810,382
47	38,396,129	49,120,889	43,687,157	19,453,015	24,234,142

* Break-even point as computed by the company's accounting department.

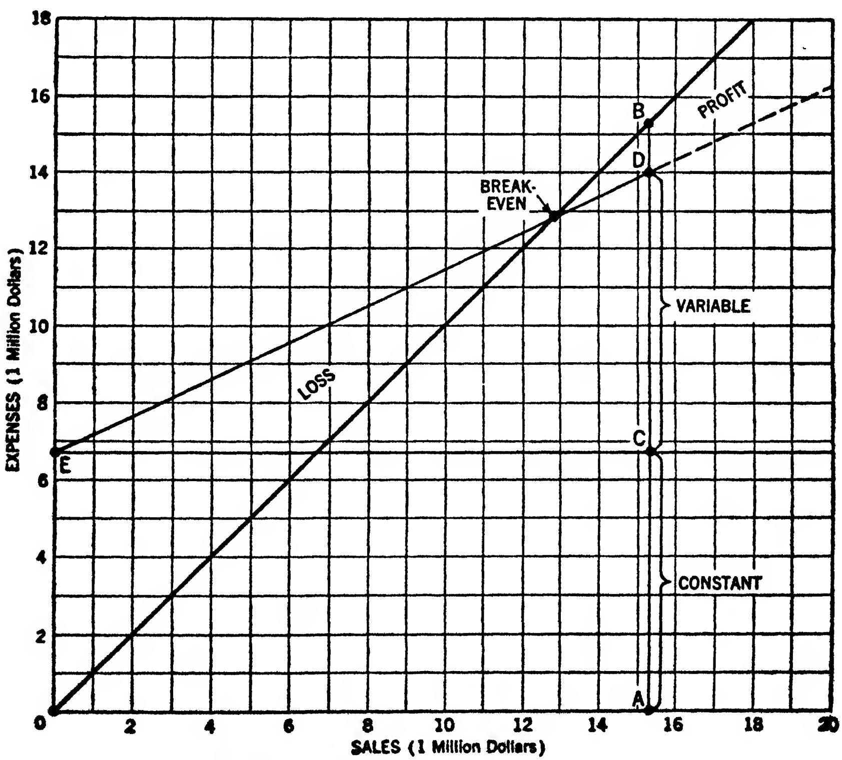

Figure 34. The XYZ Company Break-even Chart, 1938

A. THE BREAK-EVEN CHART OF THE XYZ COMPANY FOR THE YEAR 1938

The break-even chart of this company for the year 1938, was prepared as follows as explained in Chapter IV. The base of the chart Figure 34 is laid out to the scale of each division representing 10 million dollars. The annual sales for that year were $15,226,066. The point A on the base represents the annual sales. At this point, erect a vertical line A-B meeting the 45-degree line drawn through the origin O. Upon the vertical A-B, locate the point C such that the distance A-C equals to scale the constant total expense of $6,738,608, and the point D such that C-D equals to scale the variable total expenses for the above annual sales. Construct a horizontal line C-E through C and

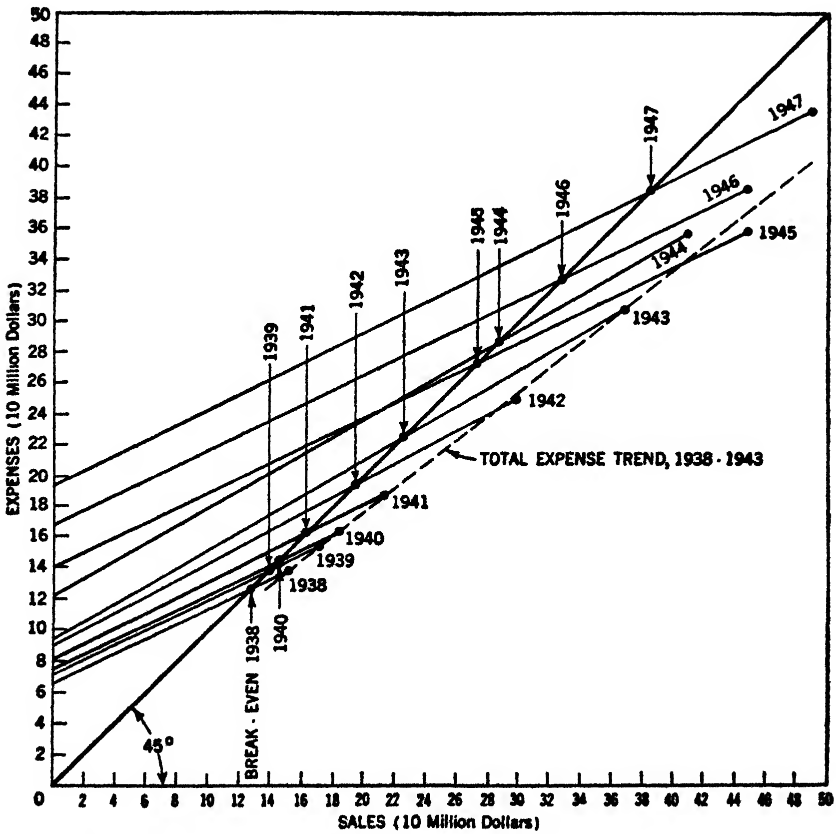

Figure 35. The XYZ Company, 1938–1947, Break-even Charts for Each Year, Profit and Loss Chart for the Period, 1938–1943

then join E and D. Where the line E-D cuts the 45-degree line is the break-even point. This point is vertically above the reading $12,900,-000 on the sales scale at the base. This compares to the computed break-even point $12,913,911, given in the above table. In practical operation the break-even point as found from the chart is quite adequate. The chart in addition to locating the break-even point in a few minutes also shows the profit which should be realized and also the variation of profit with sales. The break-even points for the years 1939 to 1947, as shown in Figure 35, when compared to those computed by the company are found in agreement.

B. THE SUCCESSIVE BREAK-EVEN CHARTS OF THE XYZ COMPANY FOR THE YEARS 1938–1947

It will be noted in the above table that The XYZ Company increased its sales from 15 millions of dollars to 49 millions of dollars during the period from 1938 to 1947. During this period of years the company gradually increased its constant total expenses. Its variable total expenses naturally increased each year with increasing sales. However, the relation of its variable expenses to total sales did not remain fixed as Table XXXIII shows.

TABLE XXXIII

THE XYZ COMPANY

Ratio of "Variable Total Expenses" to Annual Sales

Year	Percent
1938	47.8
39	49.1
40	49.6
41	50.0
42	53.6
43	57.5
44	56.9
45	48.3
46	48.6
47	49.2

If the break-even charts for all the years from 1938 to 1947 are plotted on the same chart, the results as shown in Figure 35 are obtained. Here we find not only the break-even points of each year clearly shown, but also how the constant total costs have increased year by year and how the variable costs have changed from year to year.

This composite chart clearly reveals the changes in the "economic characteristics" which the company has experienced for a period of 10 years. With the year 1944 there was a decided increase in the constant total expenses with only a slight reduction of the variable expense ratio. Accordingly, with the increase in sales not compensating for the increase in the constant total expenses, the profit was out of trend. In 1945, however, even though there was an additional constant total expense, the ratio of the variable expenses was substantially reduced so that in view of greater sales a greater profit was realized than indicated by the earlier trend. While the variable expense ratio after 1945 was held at a favorable low level, the company at the same time continued each year to increase its constant total expenses. Since the annual sales after 1945 did not increase in sufficient proportions to balance the increases in constant total expenses, the profits of the company for the years 1946 and 1947 were much less than indicated by the earlier trend from 1938 to 1943, and at the same time the break-even point went even higher. Thus the company is found in its later years in a more vulnerable position.

C. THE PROFIT AND LOSS CHART OF THE XYZ COMPANY

Figure 35 also shows the trends of profits with sales for the XYZ Company for the years 1938-1947. While during the period from 1938 to 1943 the company increased its constant total expenses each year and changed its variable expense ratios to higher levels, its total expenses and its profits followed a consistent trend in relation to sales. The trend of total expenses for these years was \$22,000,000 + 77.5% sales. From 1944 to 1947, the total expenses and hence the profits departed markedly from this trend. Either volume of sales or selling prices or both were not in balance with the company's increasing overhead.

This chart clearly shows that as a company increases its overhead, its sales must be in balance with these increases if prior trends in profits are to be maintained. This company has overexpanded its market.

VI

APPLICATIONS—PROBLEMS OF INVESTMENT

THE PROFIT AND LOSS CHART, which provides a graphic record of the trend in expenses and profits as a function of sales over a period of years, and the Break-Even Chart, which reveals the current economic characteristics of a business with its potential relation of profit to sales, both provide convenient means to management for the scientific control of operations. The analyses provided in the foregoing chapters are adaptable to the forecasting and control of operations in a manner which is not inherent in the usual accounting procedures. A well-managed business does operate by the use of an expense budget based on anticipated sales. These budgeted items of expense are standards against which the actual expenses incurred are measured. But again such standards are based on a given anticipated monthly or annual sales. Budgets of expenses are sometimes prepared for several probable monthly or annual sales and are referred to as flexible budgets. But the preparation of such budgets is time-consuming; they are not easily checked for errors and, more-

over, fail to give a comprehensive picture of the whole range of possible relationships of expenses to sales. Such budgets are also not adapted to answering readily the many problems of policy which daily occur in operating a business and which problems will be considered in this chapter.

The Break-Even and Profit and Loss Charts are useful in *analysis*, *forecasting*, and *control*. Each has its particular adaptabilities. Together they provide the tools for working with a wide range of operating problems. Problems of investment and their probable economic effects on earnings and problems of management of current expenses and their effect on the cost of production are the two main classes of problems in which these charts are particularly useful. This chapter deals with problems of investment, the following chapter with problems of management.

I. INVESTIGATION PRIOR TO FINANCING A BUSINESS

A. CURRENT OPERATIONS

Investment bankers, when approached by a corporation for the purpose of securing an underwriting of a bond issue or other forms of financing, usually require the applicant to furnish them with a report on its properties and business by an independent consulting engineer. The break-even chart of the business may form an important part of such a report. The following analysis and break-even chart was made by one of the authors for a beet sugar company which desired to float a bond issue of $1,500,000 to pay off its current indebtedness. The company owned three mills, located in two states, and contracted with the growers for the delivery of beets to designated loading stations along the railroads. The revenues and expenses were determined as follows:

The average sugar content of the beets was 14½ percent. Of this amount, only 85 percent could be extracted after allowing for a 6 percent shrinkage. One ton of beets was found to yield 100 pounds (5 percent) of dried pulp and 32 pounds (1.6 percent) of molasses. The selling prices of the products were as follows: Granulated sugar 6¢ per pound; molasses $8.00 per ton; dried pulp $30 per ton. The capacity at which the mills were operated was 200,000 tons of beets annually. It may be noted that beet sugar mills run for a period of 3 to 4 months during the year, generally from the first of October to the first of February. They are idle during the remainder of the year, and the time is spent in making repairs and renewals. A skeleton crew

is maintained during the idle period. The period of operation is known as the "campaign." The total annual revenue is determined as follows: the amount of sugar packed from one ton of beets is

$$2000 \cdot 0.94 \cdot 0.85 \cdot 0.145 = 232 \text{ pounds}$$

The annual production of all products is:

$$232 \cdot 200{,}000 = 46{,}400{,}000 \text{ pounds of sugar}$$
$$200{,}000 \cdot 0.05 = 10{,}000 \text{ tons of dried pulp}$$
$$200{,}000 \cdot .016 = 3{,}200 \text{ tons of molasses}$$

The annual revenue is:

Sugar	46,400,000 · \$ 0.06 =	\$2,784,000
Molasses	3,200 · \$ 8.00 =	25,600
Dried pulp	10,000 · \$30.00 =	300,000
Total		\$3,109,600

The annual costs are as follows: Growers' cost is based on a contract with the farmers or growers which provides that they shall be paid 45 percent of the selling price of the sugar extracted from the beets they furnish, with a minimum guarantee of \$5.22 per ton for 14½ percent sugar content and 85 percent extraction. Since the percentage on selling price prevailed, the mill-owner paid the grower at the rate of 232 · \$0.06 · 0.45 or \$6.26 per ton. Therefore, the total cost of raw materials (beets) was 200,000 · \$6.26 or \$1,252,500. This clearly is a variable total cost.

The costs of operation * were as in Table XXXIV.

TABLE XXXIV

CONSTANT TOTAL ANNUAL COSTS OF OPERATION

A Beet Sugar Company

Agriculture	\$ 175,000
Depreciation of agricultural equipment	15,000
Maintenance and repair of mills	125,000
Depreciation of mills	125,000
Factory and administrative expense	675,000
Total	\$1,115,000
Variable Total Annual Costs of Operation	
Freight and cartage	\$ 231,750
Unloading	15,000
Packing	1,000
Total	\$ 247,750

* Costs of operation in this example include some of the "costs to possess."

Interest charges, due on outstanding bonds to the amount of $1,-500,000 at 7 percent, were $105,000 annually.

Summarizing these costs, we find that the constant total costs are:

Cost from operations	$1,115,000
Cost from bond interest	105,000
Total	$1,220,000

The variable total costs are:

Growers costs (beets)	$1,252,500
Due to operations	247,750
Total	$1,500,250

These data are plotted in Figure 36.

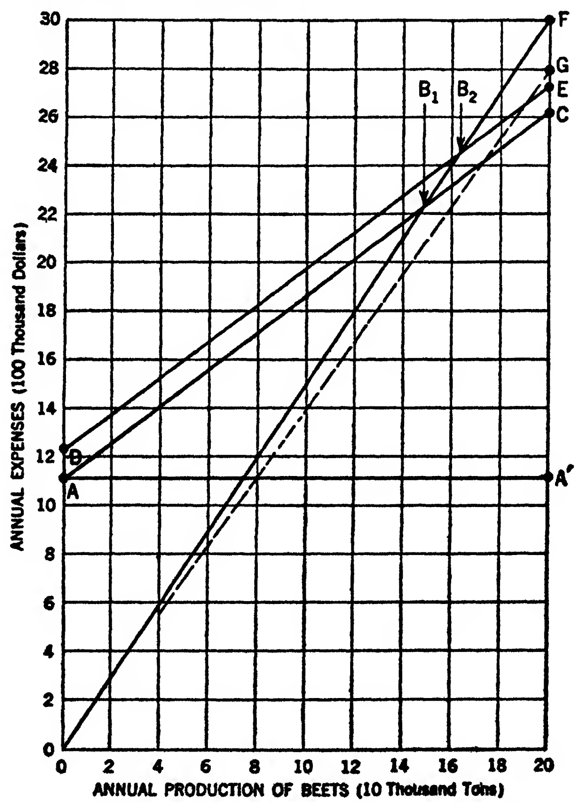

Figure 36. Break-even Chart for a Beet Sugar Mill

The line A-A′, representing the total constant costs less bond interest, is drawn at a height to scale of $1,115,000 from the base.

The line A-C, representing the additional variable total costs is drawn so that A′-C = $1,500,250. The line D-E is drawn parallel to A-C and at a distance of $105,000 above A-C. The reason why bond interest is thus separated from the constant total costs is to show when the business breaks even before bond interest is met.

The point F is located at the distance of $3,109,600 to scale above the base. Ordinates to the line O-F then represent the incomes at different annual amounts of tons of beets sliced. The broken line O-G represents the revenue from sugar only.

The completed chart shows the annual tonnage required to break even (B_1) before bond interest. It also shows that the success of the business is principally dependent on the recovery of and the market for the by-products, pulp and molasses.

The success of the business is also largely dependent on the quantity of beets which may be procured from the farmers, the sugar content of the beets, and the price per ton paid the farmers. With all these hazards the break-even point is high and the margin between success and failure is rather narrow, compared to other possible investment of funds.

B. PAST PERFORMANCE AS TO EARNINGS

One of the questions an investment banker needs to have answered, with reference to providing new funds for a business, is: How could the company have met the new fixed charges on the proposed issue of securities during the past several years of its history? This question may be answered by the use of the Profit and Loss Chart *adjusted to account for borrowings* which would not have been required if the proposed financing had previously been in effect. This problem arises generally in the case of a company which, for some years, has been lacking in working capital and has financed its operations through bank loans, the sale of short-term notes to its stockholders and others, and by other means. The additional risk capital which is to be provided through the sale of preferred stock or mortgage bonds incurs additional fixed charges on the business. These fixed charges, if the proposed risk capital had been provided earlier in its history, would have made it unnecessary for the company to borrow funds for working capital and hence any determination of how the company could have met these charges in the past requires the adjustment of its expenses in the past so as not to include the interest on its past borrowings. To illustrate how the Profit and Loss Chart may

be used to show the consequences of a new capital issue, the following case is used.

A certain company, call it the ABC Company, is capitalized by an issue of $10,000,000 of 6 percent cumulative preferred stock and $20,000,000 of common stock. Its capital is not sufficient to meet its needs and it proposes to issue $10,000,000 of 6 percent mortgage bonds. The accountants prepare a statement of annual sales and total expenses

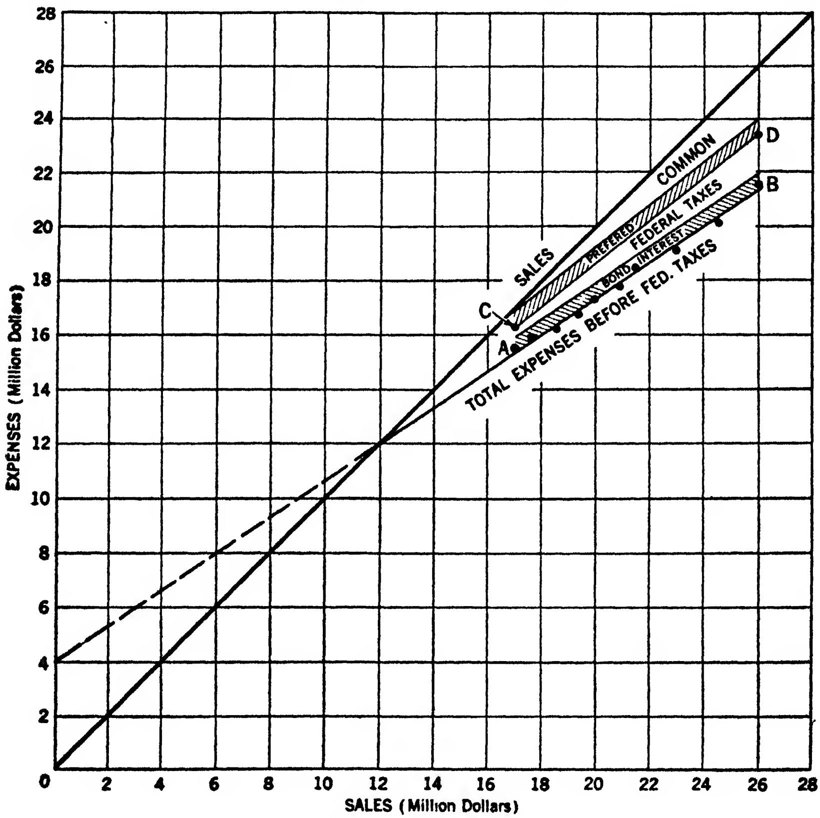

Figure 37. Profit and Loss Chart for the ABC Co.

less interest charges on borrowings for the past 10 years. These are plotted in Figure 37 and the total expense trend A-B is determined as shown. The equation of the trend line is:

$$\text{Total expense} = \$4{,}000{,}000 + 66.6 \text{ percent sales}$$

The equation of average profit before Federal taxes, P, is:

$$P = 33.3 \text{ percent sales} - \$4{,}000{,}000$$

The minimum annual sales for the period under review were $17,000,-000, whereupon the corresponding profit would be 33.3 percent of $17,000,000 — $4,000,000 = $1,660,000. The corporation, during that year, would have earned its bond interest 2.7 times. The maximum annual sales for the period were $26,000,000, resulting in an average profit of 33.3 percent of $26,000,000 — $4,000,000 = $4,660,000 which is 7.7 times the interest on the proposed bond issue. The Profit and Loss Chart of Figure 37 shows very clearly the proportion of bond interest to profits before taxes for the entire period. The profit after bond interest is subject to Federal income taxes, and the effect of these taxes is shown by the line C-D. The profit margin above C-D is available for dividends. After the dividends on the preferred stock, shown by the shaded area, are accounted for, the remainder is available for dividends on the common stock. Since stock dividends are payable only on income after Federal taxes and after bond interest, the average total disbursements before dividends follow the trend of the line C-D, the equation of which is:

$$\$2{,}800{,}000 + 79 \text{ percent sales}$$

Accordingly, the equation of average profits after bond interest and Federal income taxes available for dividends, is

$$21 \text{ percent of sales} - \$2{,}800{,}000$$

When, for example, the annual sales are $26,000,000, the profits available for dividends are 21 percent of $26,000,000 — $2,800,000 = $2,-660,000 which is 4.4 times the preferred dividend requirements.

The profit and loss chart, when prepared as shown in Figure 37, shows at a glance how bond interest, Federal income taxes, preferred dividends, and earnings on the common stock were related to profits as sales varied over a wide range. In case the departure of annual expenses from the trend is significant and the Federal income taxes vary irregularly with profits throughout the years, it is better practice to chart the actual data in each case with corresponding trend lines to show the averages over the years.

C. PROBABILITIES OF EARNINGS ON CURRENT OPERATIONS

While the past performance on earnings of a company is important to the investment banker from the standpoint of providing a proven record to support the sale of a new issue of securities of a company, it is also important to review the current budget of operations of a

company to learn the probabilities of meeting current commitments as to present fixed charges and of earnings on present stock issues. The current break-even chart of a company is useful for this purpose, as the following case illustrates.

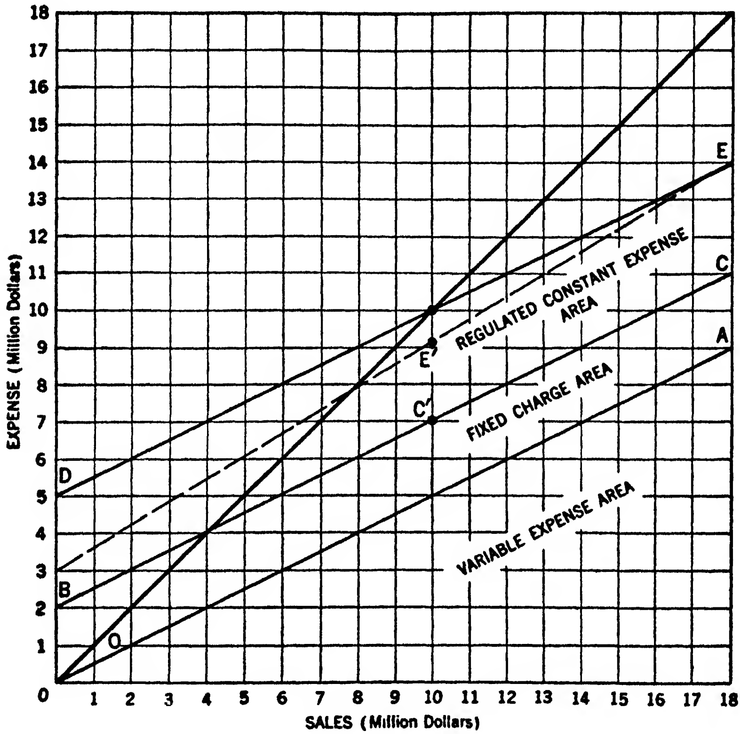

Figure 38. Break-even Chart Showing the Different Expense Areas

A company, in anticipation of annual sales of 18 million dollars, sets up a budget of expenses which results in

Fixed charges before bond interest	= \$2,000,000
Regulated constant expenses	= \$3,000,000
Total variable expenses for \$18 million sales	= \$9,000,000

This budget results in a break-even chart as shown in Figure 38, in which the line O-A defines the total variable expenses; the line B-C defines the fixed charges; and the ordinates in the area B D E C show the present budgeted regulated constant expenses. With this budget

the company will break even before interest at annual sales of 10 million dollars. The equation of profit before interest charges is

$$P = 50 \text{ percent of sales} - \$5{,}000{,}000$$

In general terms it is written

$$P = (1 - b)\,X - a$$

Let

B = the amount of bonded debt (dollars)
S = the amount of preferred stock (dollars)
C = the amount of common stock (dollars)
% = the percent of interest on the bonds or percent of dividends on the preferred stock
T = the Federal income taxes

then

1. The number of times bond interest is earned is

$$\frac{P}{\%B}$$

2. The number of times the preferred stock dividends are earned is

$$\frac{P - \%B - T}{\%S}$$

3. The percentage earned on the common stock is

$$\frac{P - \%B - T - \%S}{C}$$

However, if the company has set up a budget of regulated expenses such that these are gradually reduced as annual sales decline from C-E at $18,000,000 annual sales to C′-E′ at $10,000,000 annual sales, then the probability of earnings is determined by the total expense trend E-E′ for which the profit becomes

$$P = 38.9\%\,X - \$3{,}000{,}000$$

The method followed in the preparation of Figure 37 could also be applied to the analysis of the above data so as to bring in clear perspective the relation of earnings to sales for each class of securities for the entire range of anticipated sales. The construction of such a chart takes very little time and in a few moments the probabilities of earnings on investments and their margins of safety are quickly determined.

II. COMPARISON OF TWO OR MORE COMPANIES AS TO EARNINGS

A. The income-expense relationships of the break-even chart disclose the profit or loss in terms of sales income. But since the investors in business enterprises are concerned primarily with the probable profit per dollar invested, it becomes necessary to evaluate business from this standpoint also. If two businesses, operating at full capacity, both show the same total profit but the one business has twice the invested capital of the other, then the one is half as profitable as the other from the standpoint of the capital invested. But all investors do not share alike in the earnings.

Assume two businesses, A and B, each having earnings of $100,000 and each a total invested capital of $1,000,000. The earnings are 10 percent on the total capital invested in each company. If Business A has its capital represented by $400,000 of 7 percent preferred stock and $600,000 of common stock, then the holders of preferred shares will receive $28,000 or 7 percent on their invested capital, while the holders of common stock will be credited with $72,000 or 12 percent on their invested capital.

If Business B has only common stock in its capital structure, then each shareholder will earn 10 percent on his invested capital.

B. The difference between two businesses with respect to the probability of earnings over a wide range of sales may be shown by means of these charts, although their profit and loss statements upon superficial examination may indicate that both businesses have about the same earning capacity. A certain company, for example, let us call it Company A, shows annual sales of $2,000,000 and net profits of 15 percent on sales, or $300,000. The profit and loss statement of Company B, which manufactures and merchandises a wholly different product, also shows annual sales of $2,000,000 and net profits of 15 percent on sales, or $300,000. Let it be further assumed that both companies are operated at full capacity. An examination of the constant total costs and variable total costs shows the following:

	Company A	Company B
Constant total costs	$ 700,000	$ 200,000
Variable total costs	1,000,000	1,500,000
Total	$1,700,000	$1,700,000
Sales	2,000,000	2,000,000
Net profit	$ 300,000	$ 300,000

Upon constructing the break-even charts for each company, and superimposing them, we find some important differences in their earning characteristics.

These charts are shown in Figure 39. The one constructed with solid lines is for Company A; that with broken lines, for Company B. The two companies earn the same total profit when operated at full capacity. Company A breaks even at 70 percent, whereas Company B breaks even at 40 percent capacity. Accordingly, Company B makes a profit over a wider range of sales. It has more elasticity. It can be operated at a profit of approximately $140,000, when Company A

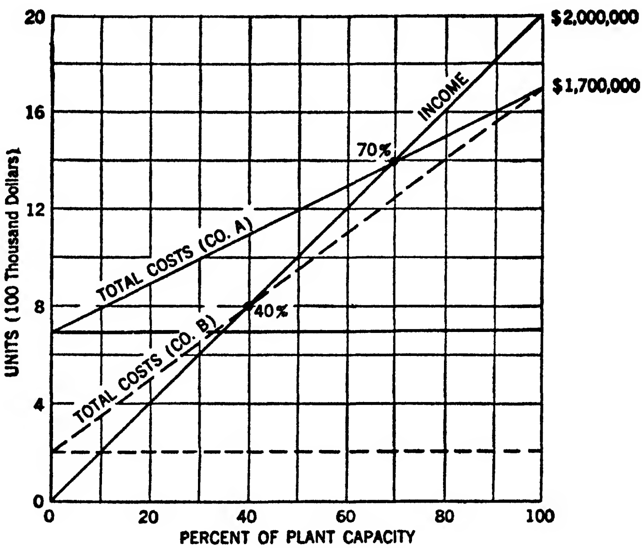

Figure 39. The Break-even Chart of Two Companies Making the Same Profit at 100 percent Capacity

shows no profit for the same volume of sales. Company B breaks even when Company A shows a loss of $300,000. Company B is typical of those industries in which there is little plant investment and consequently the fixed charges are low. The principal costs are for materials and labor. Company A, on the contrary, represents those businesses in which the fixed charges or constant total costs are high, such as highly mechanized industries. The management of Company B can discharge its help as sales decline, but Company A finds itself in a wholly different situation in a declining market, and one in which it cannot readily adjust expenses to income.

C. When a merger of two companies is contemplated, it is desirable to know what the combined profit and loss history of the two companies is. This will assist the banker in visualizing some aspects of the results of the combination of the two companies.

To illustrate, assume that there are two companies, A and B, to be merged, which have annual sales of \$1,000,000 and \$2,000,000 respectively. Company A has an expense trend derived from its profit and loss chart of

$$\$200{,}000 + 0.4X$$

Company B has an expense trend derived from its profit and loss chart of

$$\$300{,}000 + 0.55X$$

The combination expense trend applicable to the sum of the sales of the two companies and applicable only *to the condition that the sales of Company B shall always be twice the sales of Company A is derived as follows.*

The general equation of the expense line is

$$e = k + vX$$

The value k is determined by the summation \$200,000 plus \$300,-000 = \$500,000. The value v is determined as follows:

$$\begin{array}{rl} 0.4 \cdot 1 & = 0.4 \\ 0.55 \cdot \underline{2} & = \underline{1.1} \\ 3 & \big|\, \underline{1.5} = 0.5 = v \end{array}$$

Thus the combined expense line is:

$$500{,}000 + 0.5X$$

NOTE: If companies A and B have sales of \$500,000 and \$1,000,000 respectively, or \$750,000 and \$1,500,000 respectively, or, in general, when the sales of Company A are one-half those of Company B, then a profit and loss chart constructed with the above expense line will show the profit and loss of the combined sales of the two companies. If, however, there is any change in the ratio of sales of the two companies, then the above expense line is not applicable.

This is easily shown by assuming that Company A has no sales while Company B has annual sales, say, of \$3,000,000. The combined annual sales are \$3,000,000, but obviously the combined expense line is:

$$500{,}000 + 0.55X$$

If, on the other hand, Company A should have \$1,000,000 annual sales, and Company B should have no sales, then the combined expense line would be:

$$500{,}000 + 0.4X$$

Accordingly, if there are, say, 20 steel companies comprising the entire steel industry, and it is desired to construct a profit and loss chart for the entire industry, such a chart may be constructed, as shown above, that is, by adding all the individual k's to determine the k of the combination and by determining the *weighted* mean of the 20 v's to find the v of the combined expense line.

This will give a fair approximation *so long as the relative sales of the 20 companies do not materially alter the weighted average of v.*

With the combined expense trend of two companies thus determined it becomes possible to visualize the effects of the merger by comparing the combined expense trend with an estimated new trend based on determinable economies in manufacture and merchandising which are contemplated in the merger.

Suppose, for example, that in 1918 a study of a merger of the General Electric Company and the Westinghouse Electric and Manufacturing Company was undertaken. From 1910 to 1917 the General Electric Company had an annual expense trend of \$4,000,000 + 86.0 percent of sales and in 1917 had a sales income of approximately 200 million dollars. From 1907 to 1918 the Westinghouse Electric and Manufacturing Company had an annual expense trend of \$6,000,000 + 78 percent of sales. Since its sales in 1918 were approximately 96 million dollars it may be assumed that its sales income may be expected to be one-half that of the General Electric Company.

The ordinate K of the combined trend would be \$10,000,000. The slope of the trend would be

$$\begin{array}{rcl} 0.78 \cdot 1 & = & 0.78 \\ 0.860 \cdot \underline{2} & = & \underline{1.72} \\ 3 & & \underline{|2.50} \\ & & 0.833 \end{array}$$

The annual expense trend of the combination would be

\$10,000,000 + 83.3 percent of total sales

As a check on this estimate, lay out a profit and loss chart with the above annual expense trend and maximum sales of 300 million dol-

lars. Then, take the record of sales and total expenses of the two companies given in Table XXXV, combine them, plot the combined values on the chart, and see how closely the estimate approximates the trend of the plotted total expense points.

TABLE XXXV

GENERAL ELECTRIC AND WESTINGHOUSE

Year	Annual Sales General Electric	Annual Sales Westinghouse	Annual Expenses General Electric	Annual Expenses Westinghouse
		(*Thousands of Dollars*)		
1910	71,479	29,248	63,852	27,804
11	70,384	38,119	62,832	34,753
12	89,182	34,196	81,606	32,912
13	106,477	39,977	97,216	37,801
14	90,468	43,733	82,068	40,955
15	85,522	33,671	77,468	32,810
16	134,242	50,269	119,519	41,728
17	196,926	89,539	174,535	72,846

If this study should be continued, and it were estimated that by combining their sales offices and warehouses and by consolidating certain activities the ordinate k of the point of orientation K of the combined trend would be reduced $1,000,000 and the slope of the trend could also be reduced 5 percent, with no changes in selling prices, what percentage on sales would the profits be for annual sales of 300 million dollars? How does this compare with the sum of the profits of each company operating alone?

The above estimates on savings by combined operations are, of course, mere assumptions, made for purposes of illustration.

E. Another use which such a combined profit and loss chart may serve is to compare the performance of a single company with that of the industry as a whole or with that of the average of selected units in the industry. Such comparisons are desired by investment bankers to show how a company desiring financing stands with reference to an important unit in the industry.

For example, a banker may wish to know how the performance of a certain electrical manufacturing company compares with the performance of the General Electric and Westinghouse companies. Assume this comparison to take place in 1917. At this time, let us assume that the combined sales of the General Electric and Westing-

house corporations were $300,000,000. The combined trend of the total expenses as determined above shows that the total expenses in relation to the total or combined sales were $10,000,000 + 83.3 percent of $300,000,000, or $260,000,000, which in turn is 86.6 percent of the total sales. The point of orientation k ($10,000,000) will be 3⅓ percent of the combined total sales ($300,000,000). The first step in making the comparison is to lay out a profit and loss chart with the base equal to 100 percent capacity and divided into units of, say, 10, 20, 30, etc., percent. Construct the 45-degree income line. At the right-hand ordinate, locate a point at 86.6 percent of maximum income. At the left-hand ordinate, lay off a point at 3⅓ percent of maximum income, that is, at the 3⅓ percent point. Join these two points and thus locate the line of total expense. This will give a profit and loss chart laid out on the basis of percentage of maximum income capacity, instead of an income in total dollars.

Assume that the company making this comparison does a maximum business of $10,000,000 in annual sales and that its total annual expense trend is $750,000 + 80 percent of annual sales income. Accordingly, its total annual expenses at maximum sales will be $750,000 + 80 percent of $10,000,000, namely $8,750,000, which is 87.5 percent of its maximum sales income. Its k will be 7.5 percent of maximum sales income. These two percentages being known, the expense line of the company may now be added to the chart, and a comparison of the two expense lines will show the relationship desired. The student should construct this comparative chart as indicated.

III. THE EFFECT OF FEDERAL INCOME TAXES ON EARNINGS

At the present time, the problem of taxes is of considerable concern to the investors in a company's securities. To get a clear picture of what a company's economic characteristics are, it is necessary to find the trend of total expenses before taxes since the amount of taxes paid is not part of the economic performance of a company. To illustrate, the total expenses *before* taxes in relation to sales of the International Paper Company for the years 1936 to 1946 are plotted as shown in Figure 40. For purposes of comparison, the total expenses *after* taxes for the years from 1940 to 1946 are also plotted as indicated.

This chart shows that for this company the trend of total annual expenses before taxes closely approximated

$$\$26{,}000{,}000 + 72\% \text{ of sales}$$

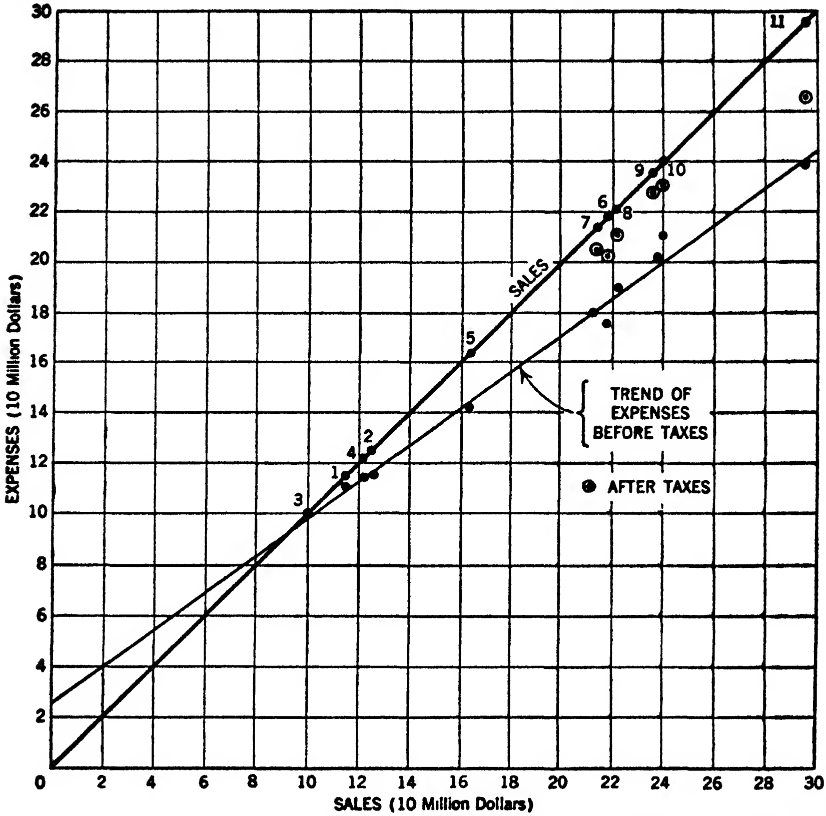

Figure 40. International Paper Co. Profit and Loss Chart, 1936 (1)-1946 (11)

From this base it is possible to estimate the effect of taxes on earnings. For example, should annual sales be 200 millions of dollars, the probable profit before taxes may be anticipated to be

$$\text{Profit } \textit{before} \text{ taxes} = (\$200{,}000{,}000 \cdot 28\%) - \$26{,}000{,}000$$
$$= \$30{,}000{,}000$$

Accordingly, the probable profit *after* taxes may be anticipated to be

$$\text{Profit } \textit{after} \text{ taxes} = \$30{,}000{,}000 - \text{taxes}$$

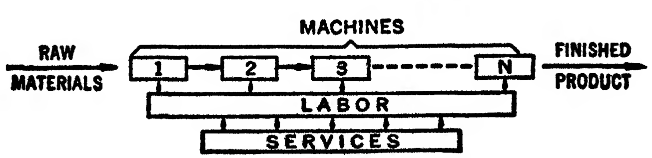

Figure 41. A Single Plant Unit Processing Lay-out

IV. THE EFFECT OF PLANT DESIGN ON THE ECONOMIC CHARACTERISTICS OF A BUSINESS

The investment banker is interested in the physical features of the factory of a company seeking funds, for several reasons. One reason is that costs of production and their control are largely influenced by the physical lay-out and the general features of the design. The extent to which the costs of producing goods at different rates of production can be regulated is dependent on the extent to which the forces of production can be adjusted or controlled. If a plant is so designed that it is a large single-processing unit and that any production whatsoever from say, 10 percent capacity to 100 percent capacity requires the running of the whole plant, the conditions of operation are as indicated diagrammatically in Figure 41.

Figure 41 illustrates a plant in which the raw materials pass through a series of processes in succession, and the labor required to run the machines and the services supporting labor are practically the same, no matter what amount of material is being processed. Some types of bakeries, sugar mills, and cement plants are designed along these lines. Because of the very nature of the design, such plants require about the same amount of labor and services when running light as when running to full capacity, and therefore their controllable costs for different rates of output are comparatively few. At the other extreme of plant design are such plants as those typified by certain forge shops in which there is a group of complete producing units. Figure 42 illustrates a design of this kind. In a forge shop, Machine 1 would represent a heating furnace and Machine 2

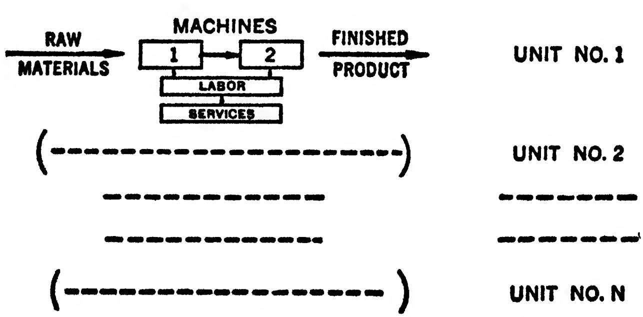

Figure 42. A Multiple Unit Plant Lay-out

a hammer. Each group of units is capable of converting raw materials into finished products. Accordingly, with a decline in demand from 100 percent capacity to, say, 75 or 70 percent capacity, one of the groups of units may be shut down and the attending labor and certain services such as the indirect labor needed to handle materials at one group and the power and heat to operate the group may be dispensed with. When the demand falls under 50 percent, another group of units may be shut down, with still further reductions in the cost of labor and some services. Therefore, a plant designed according to these principles of operation has a comparatively greater range of controllable costs, and the economic characteristics as shown by a break-even chart will be quite different from those for a plant of the type first described, particularly in showing a lower break-even point, owing to the greater change in the variable costs with output.

Between these two extremes of design there are any number of modifications and combinations, each of which establishes certain limits to the variations permissible in the controllable total costs.

It is obvious that this method of analysis has many other important applications.

VII

APPLICATIONS—PROBLEMS OF MANAGEMENT

THE BREAK-EVEN CHART of a company is useful to management because it establishes the characteristics or standards of all classes of expenses in relation to output and sales. Without such standards it is not possible to exercise scientific control of expenses as output or sales rise or fall from time to time. For example, if in a given month the manager of a factory is informed that the direct labor cost is $10,000 more than in the previous month, how can he know if the increase is justified or that it is in proportion to increased output unless he has a standard by which to judge? Budgeted regulated expenses may also easily get out of line unless compared often with standards shown in the break-even chart.

Furthermore, in every business there are numerous situations to be confronted and discussions involving expenses to be held, all of which affect the economic characteristics of the business. The Break-Even Chart method of analyses serves as a means for answering many questions of this nature, some typical examples of which follow.

A. CONTROL OF EXPENSES

Experience has shown that a break-even chart on a monthly basis is best adapted to the control of expenses since it is readily related to the monthly profit and loss statement. The standard expenses as defined by the break-even chart may be compared to the actual expenses reported in the profit and loss statement and its supporting details, and thus the *variances* or the departures from the standards are readily shown for each type of expense. Effective control of expenses must proceed by breaking down the expenses of the entire business according to divisions of the business, and according to products for each of which a separate break-even analysis should be made. In fact, every department head responsible for the expenditure of funds should be placed under control with reference to such expenditures and the break-even analysis is one of the most effective ways by which standards for expenses may be set. The following cases will illustrate how the several classes of break-even analysis required for control purposes may be prepared.

1. A Break-Even Chart for Each Product Manufactured

One of the authors of this text was appointed president of a company for the purpose of putting it on a profitable basis. The company manufactured five different products, which will be designated A, B, C, D, and E. One of the problems which presented itself was to determine the relative profitableness of each product and also how much sales were required at present prices for each to break even. The first thing that needed to be done was to assemble the facts of expense for each product manufactured. This was very difficult since the accounting system used was not adapted to this purpose. After a careful analysis and check on the known facts *and the preparation of a budget of expenses* for each division of manufacture and for the business as a whole, the following results were obtained. An examination of past sales and trends indicated that for the next year these products should be sold as follows:

Product	Annual Sales	Percent
A	$2,000,000	33⅓
B	520,000	8⅔
C	2,520,000	42
D	480,000	8
E	480,000	8
Total	$6,000,000	100

The constant total costs for the business as a whole were estimated to be $2,250,000 and the variable total costs for sales of $6,000,000 were estimated to be $3,000,000. Upon examination of the constant total and variable total cost items, it was estimated that each group of products contributed to these in the following proportions:

Product	Percentage of Constant Total Costs	Percentage of Variable Total Costs
A	40	30
B	10	5
C	35	50
D	8	10
E	7	5
	100	100

From these data it was possible to construct a break-even chart for each product manufactured, and therefore to deal intelligently with the economic problems associated with the manufacture and sale of each kind of product. Among other important information which such an analysis disclosed was the volume of sales per week which must be accomplished with each product in order to break even. In this case it was found that the break-even sales were as follows:

Product	Break-Even Sales (Weekly)
A	$31,400
B	6,100
C	37,800
D	9,100
E	4,850

The equations of expense trend of each product are as follows:

ANNUALLY

Product A expenses = $900,000 + 45% sales
" B " = 225,000 + 28.9% sales
" C " = 787,500 + 59.7% sales
" D " = 180,000 + 62.6% sales
" E " = 157,500 + 31.3% sales

MONTHLY

Product A expenses = $75,000 + 45% sales
" B " = 18,750 + 28.9% sales
" C " = 65,625 + 59.7% sales
" D " = 15,000 + 62.6% sales
" E " = 13,125 + 31.3% sales

WEEKLY

Product	A	expenses	= $17,300 + 45% sales
"	B	"	= 4,330 + 28.9% sales
"	C	"	= 15,120 + 59.7% sales
"	D	"	= 3,460 + 62.6% sales
"	E	"	= 3,020 + 21.3% sales

Thus, each product is expected to bring in, weekly, the following sales with expenses and profits as indicated.

	Weekly		
Product	Sales	Expenses	Profits
A	$ 38,500	$ 34,600	$ 3,900
B	10,000	7,220	2,780
C	48,500	44,120	4,380
D	9,250	9,240	10
E	9,250	5,910	3,340
	$115,500	$101,090	$14,410

Apparently Product D needed to be redesigned for more economical production at this volume of sales or the processes of its manufacture improved or it should be dropped.

With these facts in its possession the management was able to determine not only the amount of sales of each product needed to break even but also the extent to which each product was expected to contribute to the profits of the business not only by sales but also by the control of expenses. The above facts would not be available through the break-even analysis of the business as a whole.

2. *A Break-Even Analysis for Each Division of the Business*

A certain company * manufactures its products in two plants, one located in the East and the other in the Midwest. It has four division offices for supervision of its sales; each one has a number of branch offices under its direction. Its general offices are located in New York City. The management needs to know how much it costs to manufacture its products in each of its plants and also how much it costs to

* One of the authors was vice president and general manager of this company.

deliver its products to its customers in each territory which it serves. The company manufactures a bulk product which is sold by the pound. Without going into elaborate detail, the results of analysis are as follows.

a. *Total Annual and Monthly Sales and Expenses.* The annual sales and expenses of the business for the approaching year are estimated to be as follows.*

Annual sales	$2,555,000
Annual expenses of manufacture and administration	1,200,000
Annual expenses of distribution	1,000,000
Total expenses	$2,200,000
Annual profit	355,000
Monthly sales	$212,917
Monthly expenses of manufacture and administration	100,000
Monthly expenses of distribution	83,333
Total expenses	$183,333
Monthly profit	29,584

To assure this profit, the expenses of each department of the business must be brought under control. Since the break-even analysis for manufacture has been given adequate consideration in previous examples, the analysis of the expenses of distribution will be emphasized in this example.

b. *Expenses of Distribution.* The total monthly budget of the expenses of distribution was found to be as follows.

	Total	Fixed	Variable
General sales office (New York)	$ 7,000	$ 7,000	$——
Division expense	11,600	11,600	——
Branch expense	50,500	40,000	10,500
Freight expense	14,233	——	14,233
Total	$83,333	$58,600	$24,733

With anticipated monthly sales of $212,917, it appears that the trend of total distribution expenses per month should be

$$\$58,600 + 11.6\% \text{ of sales}$$

But each territorial division of the business must do its part if the company is to be successful. What should be expected of each of the territories? The monthly budget of operations of each territory was found to be as follows.

* This is taken from an actual case but the figures are given in round numbers.

	Eastern	New England	Central	Western
General sales office *	$ 2,100	$ 1,180	$ 1,000	$ 2,720
Division expense	3,400	2,300	1,800	4,100
Branch expense	13,300	9,400	9,100	18,700
Freight expense	3,700	3,800	2,500	4,233
Total	$22,500	$16,680	$14,400	$29,753
Constant	16,000	11,500	10,200	20,900
Variable	6,500	5,180	4,200	8,853
Sales	64,300	36,000	30,600	82,017

* General sales office expense is apportioned to the territorial division in proportion to anticipated sales.

Accordingly, the probable expenses of each territorial division should follow the trends as stated below:

Eastern	$16,000 + 10.1% sales
New England	11,500 + 14.4% sales
Central	10,200 + 13.7% sales
Western	20,900 + 10.8% sales

How much must each territorial division sell to break even *on its own expenses?*

From the above equation these are found to be:

Eastern $$\frac{\$16{,}000}{1 - 0.101} = \$17{,}800$$

New England $$\frac{\$11{,}500}{1 - 0.144} = \$13{,}450$$

Central $$\frac{\$10{,}200}{1 - 0.137} = \$11{,}900$$

Western $$\frac{\$20{,}900}{1 - 0.108} = \$23{,}400$$

Total $66,550

But the territorial divisions through their sales must also carry the expenses of manufacture and administration. These, as noted above, amount to $100,000 monthly for sales of $212,917.

An analysis of the functional nature of each item of these expenses shows that $55,000 is constant and $45,000 is variable.

Accordingly, the trend of monthly expenses of manufacture and administration is:

$55,000 + 21.1% sales

To find the break-even point for the business as a whole, the trend of total expenses of the business as a whole must be determined. This trend is:

Manufacture and administration	\$55,000 + 21.1% sales
Distribution	58,600 + 11.6% sales
Total	\$113,600 + 32.7% sales

From this trend, it is found that the break-even point of the business as a whole is

$$\text{Monthly break-even} = \frac{\$113,600}{1 - 0.327} = \$169,250$$

How much business should each territorial division do to meet the break-even requirements of the business as a whole? To answer this question the expense of manufacture and administration must be apportioned to each of the territorial sales divisions. One method of making such an apportionment is to distribute the constant expenses of manufacture and administration to the territorial divisions according to their anticipated sales. That is, according to the following percentages:

Division	Anticipated Sales	% of Total
Eastern	\$64,300	30.2
New England	36,000	16.8
Central	30,600	14.7
Western	82,017	38.3
Totals	\$212,917	100.0

Each division would also carry the variable expenses of manufacture and administration (21.1%). Accordingly, each territorial division, to absorb its proportion of the expenses of the business as a whole, must meet its own expenses of operation plus its proportion of the manufacture and administration expenses as above defined. This results in:

Division	Own Expenses	Proportion of Manufacture and Administration Expense	Total
Eastern	16,000 + 10.1% sales	16,550 + 21.2% sales	32,550 + 31.3% sales
New England	11,500 + 14.4% sales	9,250 + 21.2% sales	20,750 + 35.6% sales
Central	10,200 + 13.7% sales	8,100 + 21.2% sales	18,300 + 35.8% sales
Western	20,900 + 10.8% sales	21,100 + 21.2% sales	42,000 + 32% sales

Each territorial division to carry its portion of the business as a whole will break even as follows:

Eastern Division

$$\text{Break-even} = \frac{\$32{,}550}{1 - .313} = \$47{,}250$$

New England Division

$$\text{Break-even} = \frac{\$20{,}750}{1 - .356} = \$32{,}200$$

Central Division

$$\text{Break-even} = \frac{\$18{,}300}{1 - .358} = \$28{,}150$$

Western Division

$$\text{Break-even} = \frac{\$42{,}000}{1 - .32} = \$61{,}650$$

TOTAL $169,250

The profits anticipated from each territorial division are:

Eastern Division

$$\begin{aligned}\text{Profit} &= \text{sales } (1 - b) - a \\ &= \$64{,}300\ (.687) - \$32{,}550 \\ &= \$11{,}850\end{aligned}$$

New England Division

$$\begin{aligned}\text{Profit} &= \$36{,}000\ (.644) - \$20{,}750 \\ &= \$2{,}550\end{aligned}$$

Central Division

$$\begin{aligned}\text{Profit} &= \$30{,}600\ (.642) - \$18{,}300 \\ &= \$1{,}454\end{aligned}$$

Western Division

$$\begin{aligned}\text{Profit} &= \$82{,}017\ (.68) - \$42{,}000 \\ &= \underline{\$13{,}730}\end{aligned}$$

TOTAL
PROFIT = $29,584

Without an analysis of the above kind it is not possible to establish a rational norm of anticipated expenses and profits for each division of the business, and therefore no rational basis of management and control can be established.

3. *A Break-Even Chart for Each Department*

The manager of a department of manufacture is in charge of expenditures for labor both direct and indirect, for materials both direct

and indirect, and for certain items of factory expense such as maintenance and repairs. Other items of expense charged to his department may not be completely under his control and may be shared with other department heads on the same basis of apportionment of such expenses. If, for example, there is a central toolroom serving several departments, the responsibility of the manager of a given department for his particular portion of the toolroom expenses is not always easily determined. Other items, properly chargeable to the cost of manufacture of a given product such as depreciation, insurance, local taxes, heat, light, and power, are not under the control of the manager of any particular department and hence no one manager can be held accountable for them.

Accordingly, no control of expenses incurred by the manager of a given department can be inaugurated until the accounting department sets up a budget of the items of expense for which the manager can be held responsible. In small manufacturing companies, a given production division may be responsible for the partial or complete manufacture of several types of products. A forge shop, a foundry, a punch press department, and an assembly department, in which all the products a company manufactures are assembled, are examples of such divisions in manufacturing operations. The preparation of a break-even chart to be used for control purposes in such cases demands that the unit of output be determined first. In the case of a forge shop in which the forgings are all of the same general type, the unit of output may be the pound. The same is true of a foundry, again provided that the castings are of the same general character.

In those cases where the output may be measured in pounds, a monthly break-even chart, as shown in Figure 43, may be prepared and used for control purposes. The base of the chart is laid out in units of 1,000 pounds per month. The vertical ordinates are laid out to the scale of 1,000 dollars. The income lines may be laid out for several probable unit selling prices per pound to show the probable maximum break-even points for probable maximum and minimum selling prices. In the example selected for illustration, "Department A," the selling price per pound is fixed at 22.5¢. How can the selling prices be determined of *a part such as a forging or a casting* which is unfinished in the department to which the break-even chart relates and which is later to be machined and assembled in another department as part of the product as sold? The writers have found that for control purposes the probable selling price may be found by the following method:

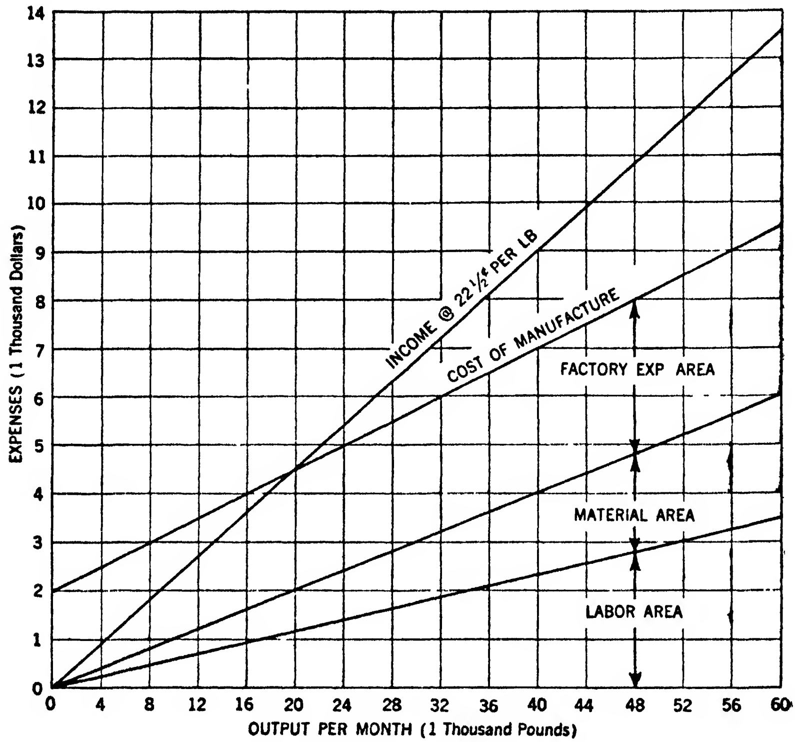

Figure 43. Budget of Monthly Expenses in Department A

a. Find the ratio of the *budgeted cost* of manufacture of the completed product to the selling price of the completed product.
b. Divide the budgeted cost of manufacture of the department by the above ratio to find the corresponding probable income. In the example shown for illustration in Figure 43, the budgeted output of Department A is 60,000 pounds per month. The cost of manufacture for the *budgeted output* is estimated to be $9,500.

The ratio of the budgeted cost of manufacture of the completed product to its selling price is approximately 0.70. Dividing $9,500 by 0.70 there is obtained the approximate quantity $13,500 which is equivalent to a selling price of 22.5¢ per pound.

To show how the chart is useful for control purposes, let it be assumed that in a given month the output is 48,000 pounds. What should the factory expense and the material and labor costs for this output be? The chart shows that the factory expense should be $3,200, the

materials cost should be $2,000 and the labor cost $2,800. These may now be compared to the actual costs reported by the accounting department and appropriate action, if needed, may then be taken. The break-even chart may be accompanied by a tabular budget each month if the business is one in which the monthly production varies over an appreciable range of output.

The following Figure 44 is reproduced from the writers' files to illustrate the form of such a budget as devised and used for a particular plant of a business manufacturing a bulk product sold by the pound. The explanations or comments were not filled in, in this report,

1947 BUDGET REPORT NO. 7.

MONTHLY REPORT OF PLANT "A" FOR MONTH ENDING June 1947

EXPENSES	AMOUNT APPROPRIATED FOR MONTH	EXPENDED THIS MONTH		EXPLANATION OR COMMENT
Raw Materials Used	$ 12951.37	10 797	45	
Direct Labor	4628.00	4 087	80	
Foremen's Salaries	810.00	785	16	
Operating Supplies Used	602.91	653	78	
Packing Supplies Used	1838.00	1 734	37	
Repairs Productive Depts.	1925.00	1 525	29	
Fuel	2548.00	1 637	89	
Taxes	169.00	187	28	
Fire Insurance	328.14	300	41	
Total Plant Expenses	37550.48	32 233	83	

Figure 44. A Typical Tabular Weekly Budget and Report

because an accompanying letter was substituted. If the management thinks in terms of cost per pound, it may be found by Figure 43 that at a monthly output of 60,000 pounds the cost per pound is 15.83¢, at 48,000 pounds per month the cost is 16.66¢, and at 28,000 pounds per month the cost is 19.64¢ per pound. If, for example, it is anticipated that in Department A the output for any given month is to be 56,000 pounds, then the budget for the major items of the cost of manufacture will be:

Factory expense	$34,000
Materials	23,500
Labor	32,500
Total	$90,000

For effective control, these major items of expense should be broken down into their details and according to their account classifications. The data of the break-even charts for all the departments, when combined, will, of course, give the break-even chart for the business as a whole.

B. ADAPTATION TO EXPENSE CHANGES

1. *Variable Total Expenses*

The several rounds of wage increases and in materials costs which have occurred in the past few years have posed some serious problems to management. When the increases in wages and materials costs are reflected in the break-even chart, the effect of these charges on earnings is brought to sharp focus. How is the break-even chart to be adapted to the increased expenses?

To illustrate, let it be assumed that the labor cost of a given manufacturing company is 30 percent of the selling price and that a 10 percent wage increase is granted. Let it be assumed further that before the wage increase is granted, the trend of total annual expenses of the business is:

$$e = \$500{,}000 + 74\% \text{ of sales}$$

The new trend in total annual expenses will be reflected wholly in the variable costs which, since their increase is 3 percent of the selling price of the product, will now be 77 percent of sales. The new trend of total annual expenses will therefore be:

$$e = \$500{,}000 + 77\% \text{ of sales}$$

If, for example, the company is presently operating with annual sales of $3,000,000, the profit before the 10 percent wage increase is:

$$\begin{aligned} P &= X(1-b) - a \\ &= \$3{,}000{,}000\,(0.26) - \$500{,}000 \\ &= \$280{,}000 \end{aligned}$$

After the 10 percent wage increase is granted, the profit will be 3 percent less on sales of $3,000,000 or $280,000 − $90,000 = $190,000; a decline of 32 percent in profits.* For the company to make the

* The student should construct the break-even chart for before and after wage increase, and note the change in the break-even point.

same profit it did before granting the wage increase of 10 percent, it will now have to increase its sales to an amount determined as follows:

Let $x' =$ the new sales
$x =$ present sales
$b' =$ the new variable cost ratio
$b =$ the present cost ratio

Then, to make the same profit as before:

$$x'(1-b') - a = x(1-b) - a$$

or

$$x' = x\frac{(1-b)}{(1-b')} = \$3{,}000{,}000 \cdot \frac{0.26}{0.23} = \$3{,}390{,}000$$

Accordingly, in this situation, the sales must be increased by 13 percent if the company is to make the same profit after granting a 10 percent wage increase.

2. Constant Total Expenses

The growth of a business frequently raises the question of plant enlargement. On such occasions a prudent management will forecast the probabilities of profits and the shift in the range of sales in which a profit may be made. Plant enlargement results in an increase in fixed factory expense. There are increases in charges for depreciation, higher insurance and taxes, increased maintenance and repairs, and in other charges. Assume, for example, that a certain manufacturing business is operated with constant total expenses of \$550,000 per annum and that the ratio of variable total expenses to corresponding sales is 0.45. The business will break even at sales of

$$X = \frac{\$550{,}000}{1-0.45} = \$1{,}000{,}000$$

If the sales value of the product at 100 percent capacity is \$1,500,000, the business would break even at 66⅔ percent capacity. The profit at 100 percent capacity would be

$$P = X(1-b) - a$$

where $X = \$1{,}500{,}000$

$b = 0.45$
$a = \$550{,}000$
$P = \$275{,}000$

If the plant is enlarged 33⅓ percent of present capacity, the sales value of the products of the enlarged plant, when run at the new full capacity, would be \$2,000,000. The constant total costs (a) would also be increased as above indicated. Assume this increase to be 20 percent, giving constant total costs for the enlarged business of \$660,000. Assume (b) to be unchanged. The business will now break even at sales of

$$X = \frac{\$660{,}000}{1 - 0.45} = \$1{,}200{,}000$$

If a profit of \$275,000 is to be made as before, when the plant was run at old full capacity and sales were \$1,500,000, it is found that the sales must now be equal to

$$X = \frac{P + a}{1 - b}$$

$$= \frac{\$275{,}000 + \$660{,}000}{1 - 0.45} = \$1{,}700{,}000$$

Accordingly, there must be at least \$200,000 increase in business to justify the plant expansion. When the enlarged plant is operated at full capacity, that is, when sales are \$2,000,000, the profit will be

$$P = \$2{,}000{,}000\,(1 - 0.45) - \$660{,}000 = \$440{,}000$$

If, however, the increased business should not be realized, and maximum sales were \$1,590,000, the profit would then be

$$P = \$1{,}500{,}000\,(1 - 0.45) - \$660{,}000 = \$165{,}000$$

which is \$110,000 less than before the plant was enlarged. And, if sales should decline to \$1,000,000 annually, the business, instead of breaking even, would suffer a loss of

$$P = \$1{,}000{,}000\,(1 - 0.45) - \$660{,}000 = \$110{,}000$$

QUESTION: If the break-even point of a business is 75 percent of plant capacity, is there a hazard in having a single customer take, say, 30 percent of the output? If you were the customer, and knew that you were taking 30 percent of the manufacturer's output, would you press him for a price reduction?

3. Constant Total and Variable Total Expenses

Very frequently a company finds it necessary to change its methods of manufacture or its system of marketing or both, in order to meet

new economic conditions. Sometimes it is found desirable to modernize the plant by installing new machinery and using new methods of manufacture as a means to lowering the costs of manufacture. Any changes of this sort will alter the economic characteristics of the business, and it is therefore desirable to disclose the economic effects of such changes by means of the break-even chart.

Let us assume, for example, that a certain manufacturing business has the economic characteristics shown by the solid lines of the break-even chart of Figure 45 and that the management decides to install new machinery and revise its methods of production. It is estimated that by these measures the constant total costs of the business will be increased from $500,000 annually to $800,000, owing primarily to increased interest charges, depreciation, and other fixed charge items. It is also estimated that the variable total costs, which are $1,700,000 annually at 100 percent capacity, will now be reduced to $1,080,000, owing to reductions in labor costs and other operating expenses.

The effect of these changes may be shown by plotting a new break-even chart and comparing it with the former one as shown in broken lines in Figure 45. It is found that the business may now be expected to break even at 60 percent of the original capacity instead of 70 percent as formerly, and that the profits at 100 percent of original capacity are estimated to be $520,000 instead of $200,000, or 160 percent greater. These changes are expressed in terms of the original capacity, for in all probability the total capacity will also be increased. The example chosen for illustration happens to work out satisfactorily and indicates that the suggested changes in methods of manufacture are desirable. It is not to be assumed, however, that this will be true in all instances, for sometimes it is found that the break-even point is raised instead of lowered, even though a slight increase in profits may be indicated at 100 percent original capacity. Under such circumstances it must be decided whether or not the probabilities for increased sales will justify the change. If sales decline below a limit point L (see Figure 45), the company will have a greater loss than formerly.

Those industries which in prosperous periods have mechanized their plants and substituted the higher fixed charges of the machine for the variable costs of labor have found themselves at a disadvantage during depression periods because of the higher costs per unit of product when the rate of production is low. This situation is indicated by the upper portion of Figure 45, which shows the costs per

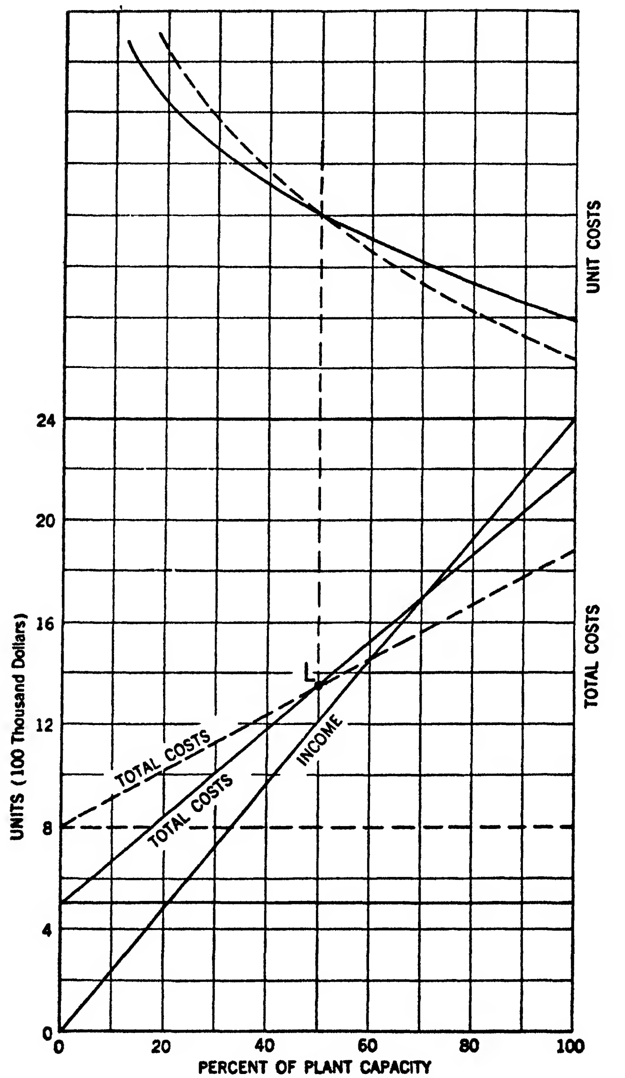

Figure 45. The Effects of Mechanization on the Income-Expense Characteristics and on Unit Costs

unit of product in the two situations. So long as the business is operated above the limit point L, the more completely mechanized plant can produce at lower unit costs. Below the limit point L, the original plant has the advantage.

C. ADAPTATION TO CHANGE IN SELLING PRICE

1. Break-Even Chart on the Dollar Base with 45° Sales Line

To illustrate the effect of price change on the break-even chart of the above type, a situation as shown in Figure 46 is referred to. In this case, a company is capable of selling \$140,000 worth of goods each month at a selling price of \$14 per unit. With this selling

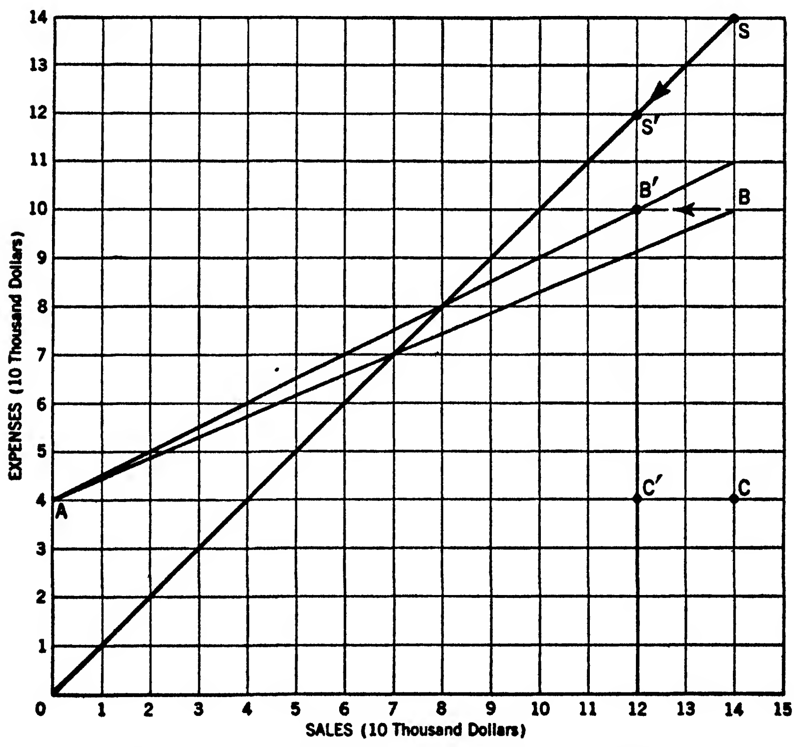

Figure 46. The Effect of Price Adjustment on the Expense Trend

price, the total monthly expenses of the business *in relation to sales* are:

$$E = \$40{,}000 + 42.8\% \text{ of sales}$$

Circumstances compel a price reduction to \$12 for each unit. Accordingly, the same quantity of goods will sell for \$120,000 and therefore

the point S on the sales line of Figure 46 will move down to S′. But it will cost just as much to produce the goods, hence the expense point B will move horizontally to the left to B′. The line A-B′ then becomes the trend of total expenses when the selling price of the product is reduced to $12 per unit. The new expense trend for a selling price of $12 per unit is:

$$E = \$40{,}000 + 50 \text{ percent of sales}$$

Expressed in general terms, the new variable expense ratio resulting from price change is found as follows:

Let $p =$ percent price change
$v =$ variable total expenses for x dollar annual sales
$e =$ present expenses in relation to sales
$= a + bx$
$e' =$ expenses after price change in relation to sales
$= a + b'x'$
$= a + b'[x(1 \pm p)]$
$x =$ annual sales at present prices
$x' =$ annual sales at changed prices
$= x(1 \pm p)$

From which it appears that with price change, b becomes $b'(1 \pm p)$ which means that the new variable expense ratio caused by price change is $b' = \dfrac{b}{1 \pm p}$

Another approach to the determination of b′ is as follows. From Figure 46 it is found that

$$b = \frac{B\text{-}C}{A\text{-}C}$$

and

$$b' = \frac{B'\text{-}C'}{A\text{-}C'} = \frac{B\text{-}C}{A\text{-}C'}$$

accordingly

$$\begin{aligned} B\text{-}C &= b\,(A\text{-}C) \\ &= b'\,(A\text{-}C') \end{aligned}$$

whence

$$b'\,(A\text{-}C') = b\,(A\text{-}C)$$

or

$$b' = b \frac{A\text{-}C}{A\text{-}C'}$$

but $A\text{-}C = x$
and $A\text{-}C' = x' = x\,(1 \pm p)$
Therefore

$$b' = \frac{b}{(1 \pm p)}$$

For example, if the trend of total expense to sales is

$$\$9{,}000{,}000 + 80\%\,X$$

and there is a price reduction of 10 percent, then the trend of total expense in relation to the new and reduced income from sales X′ becomes

$$\$9{,}000{,}000 + \frac{80}{1 - 0.10}\,X' = \$9{,}000{,}000 + 88.8\%\,X'$$

Letting X represent the income from sales for any selling price, the prime character may be dropped.

The profit for a given income from sales is written:

$$P = X\,(1 - b) - a$$

At the former selling price, the profit is zero, or the break-even point occurs, when

$$O = X\,(1 - 0.80) - \$9{,}000{,}000$$

or

$$X = \$45{,}000{,}000$$

At the new selling price (10 percent less), the break-even point is

$$O = X\,(1 - 0.888) - \$9{,}000{,}000$$

or

$$X = \$80{,}000{,}000 \text{ approximately}$$

Thus, a 10 percent reduction in selling price will result in raising the break-even point of this business from \$45,000,000 to \$80,000,000.

Under the old selling price, the business made a profit on sales, after $45,000,000, of 20 percent. At $80,000,000 sales this would amount to $7,000,000.

A 10 percent reduction in selling price would thus wipe out this profit.

In those businesses in which the variable cost ratio (b) is high, the effect of price reduction on profits is severe.

It is also the case in such types of business, when materials and freight costs are high and are the occasion for a high variable cost ratio, that an increase in raw materials costs or freight rates or both will have serious effects on earnings. Meat packing and fertilizer manufacture (P_2O_5) are examples of such industries. In the case of some businesses, the unit cost may *increase* with an increase in the *volume* of sales, as in the case of a telephone company where the increment of cost of new connections may be greater than the increment of income.

2. *Break-Even Chart on a Physical Output Basis*

When the effect in change of selling price is to be recorded on the break-even chart, constructed on an output basis, as shown in Figure 43, the only alteration that need be made is to construct a new sales line with a slant according to the new unit price. The writers have found it convenient in the study of the effect of selling price on the earnings from the sale of any particular product, to construct several sales-income lines, particularly the maximum and the minimum of the range under discussion. The general principles of construction of a break-even chart with the base laid off in physical units and the ordinates in dollars are such that both the break-even point and expense trend calculations must be made in terms of both quantity and price.

For instance, the trend line of sales is

$$y = Qp$$

where $y =$ sales
$Q =$ quantity
$p =$ unit price

and in which Qp takes the place of x.

The trend line of expense is

$$e = a + bx = a + bQp$$

Accordingly, the quantity at which the business will break even is that found by the equation

$$Qp = a + bQp$$

or

$$Q = \frac{a}{1 - bp}$$

Also the cost per unit of output is

$$c = \frac{e}{Q} = \frac{a + bQp}{Q} = bp + \frac{a}{Q}$$

3. *Increase in Sales Required to Balance a Specific Reduction in Selling Price*

The purpose of price reduction is usually to hold the market against competitors or to increase volume of sales through offering more attractive prices than competitors. It also makes the product available to purchasers in the lower income classes. The pricing of the product is a problem continually facing the manufacturer. The sales department, as a rule, is asking for lower prices to reduce the sales resistance. When price reductions are considered, the manufacturer is confronted with a number of problems. He may well ask himself: How much greater must the sales be to make the same profit? At what volume of sales will the business break even at the lower selling price? Can he answer these questions intelligently if he does not know the economic characteristics of his business?

Let us assume, for example, that a businessman is confronted with the suggestion that prices be cut 10 percent on the theory that it will stimulate sales and, furthermore, will bring his prices in line with those of competing products. The constant total costs of the business, let us assume, are \$250,000 per annum, and b is 0.40. The sales at present prices are assumed to be \$500,000 per annum, and hence the profit is

$$\begin{aligned} P &= X(1 - b) - a \\ &= (\$500{,}000 \cdot 0.60) - \$250{,}000 \\ &= \$50{,}000 \end{aligned}$$

What must the sales be at the reduced selling price, if the same profit is to be made? The ratio of variable total costs to corresponding sales on the basis of present prices is $b = 0.40$. If prices are reduced by 10

percent, then b becomes $0.40 \div 0.9 = 0.444$. Then the sales required to yield a profit of \$50,000 must be

$$X = \frac{P + a}{1 - b}$$

$$= \frac{\$50{,}000 + \$250{,}000}{1 - 0.444}$$

$= \$530{,}000$ approximately, or 6 percent above present volume

If sales are not increased, the profit will be reduced to

$$P = (\$500{,}000 \cdot 0.556) - \$250{,}000$$
$$= \$28{,}000 \text{ or a reduction of 44 percent}$$

Accordingly, if the 10 percent price reduction suggested is to be justified, there must be more than a reasonable probability of a sales increase of more than 6 percent, and this probability must be weighed against the risk of a reduction in profits of 44 percent if sales are not increased after prices are lowered.

APPENDIX

The break-even chart has been applied to a large number of companies and whole industries, and at times a few interesting modifications in the general procedure have been found very helpful. The three following particular applications have been selected to illustrate some interesting cases in which the break-even chart has been adapted to situations where expenses and incomes have particular characteristics.

1. THE BREAK-EVEN CHART IN THE NATIONAL GAS BUSINESS

It may be found more convenient at times to rearrange the cost lines in the chart by placing the variable total cost lines at the bottom of the chart and the constant total cost lines immediately above. That arrangement is used in the following example quoted from the *Gas Age Record* of March 17, 1934.* This case also illustrates a situation in which the sales line reflects quantity pricing.

The recent increase in business activity has also affected the natural gas industry, resulting in augmented profits, or in some cases, decreased

* By Victor F. Hasenoehrl, B.S., Com. E.; Lecturer in engineering economics, Brooklyn Polytechnic Institute; formerly with Ford, Bacon and Davis, Inc.

losses in the major operating divisions of the industry. Natural gas wells, pipe-lines, and other structures and equipment which were operated at low use factors at a small profit or loss, are now operated at higher use factors or flows. Their profits have been increased or their losses decreased.

It is then of great interest to the executive in the natural gas industry to know what annual or ultimate production a gas well must deliver or at what use factor a pipe-line must be operated in order to be profitable. The profits at a certain use factor or production are usually known, but the use factor or flow at which operations become profitable is not always accurately calculated or estimated.

The Break-Even Chart as developed by Professor Walter Rautenstrauch of Columbia University, is a graphical representation of revenues, costs, and profits or losses at various use factors, flows, deliveries, etc. Once constructed it shows at a glance the profits or losses of a natural gas well, a pipe-line, etc., at various deliveries, and also the flow or use factor at which no profits are made but also no losses are incurred, the so-called "break-even point." In addition it shows graphically the effect of changes in revenues or fixed and variable operating costs on profits or losses at certain deliveries. The break-even chart has been applied to many businesses and industries, but some of its application to the natural gas industry have not as yet to the author's knowledge been published.

The construction of the chart is simple. On the horizontal scale or abscissa are laid off the use factors, deliveries, etc., of the pipe-line, gas well, or other structure which is being studied. On the vertical scale or ordinate are measured the fixed and variable operating costs incurred and the revenues derived at various use factors, deliveries, etc.

The following examples show the application of the break-even chart to hypothetical gas wells and a hypothetical pipe-line. There are, of course, many other applications of the chart in the natural gas industry. The examples below serve only to illustrate the construction and use of the break-even chart.

The following data are available as to gas wells:

Average drilling cost, including dry hole allowance and leasing expense	\$8,000
Annual interest rate on investment	6%
Annual operating and overhead costs per well	\$500
Annual royalty	⅛ of gross revenue
Estimated ultimate natural gas reserves per well	Varying from 20,000 MCF to 270,000 MCF
Estimated productive life of average gas well	10 years
Price of gas at well per MCF	15¢
Discount factor applied to future revenue and costs	0.70

From these data the following table can be constructed:

Estimated ultimate natural gas reserves in MCF	20,000	120,000	170,000	270,000
Gross revenue in dollars	3,000	18,000	25,500	40,500
Present worth of gross revenue in dollars	2,100	12,600	17,900	28,350
Cost of well in dollars	8,000	8,000	8,000	8,000
Present worth of interest on investment in dollars	3,360	3,360	3,360	3,360
Present worth of royalty in dollars	260	1,580	2,240	3,540
Present worth of operating and overhead costs in dollars	3,500	3,500	3,500	3,500
Present worth of all costs in dollars	15,120	16,440	17,100	18,400
Present worth of profit or loss in dollars	13,020 (*loss*)	3,840 (*loss*)	800	9,950

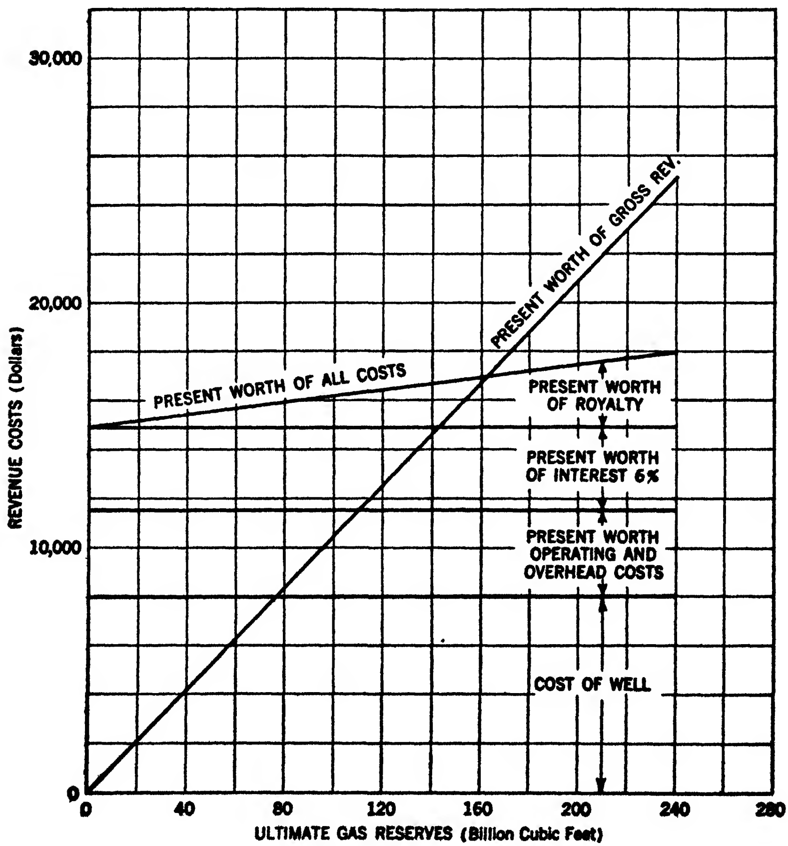

Figure 47. The Break-even Chart of a Natural Gas Well

The break-even chart based on this tabulation is shown in Figure 47. It will be seen that, based on the above assumptions, wells whose estimated reserves are less than the approximately 160,000 MCF are unprofitable. This example illustrates the application of the break-even chart principle to natural gas wells the productivity of which is, of course, not controlled by the owners of the wells. On the other hand, the owners may be able to decrease their fixed and variable costs. If, for example, the annual interest rate on the investment is taken as 4 percent and annual operating and overhead costs are reduced to $300 per well per year, gas wells whose estimated reserves are in excess of 130,000 MCF become profitable. It should be noted that the chart, as constructed, is valued only for wells which are being operated. Dry wells are not considered.

On a pipe-line not only fixed and variable costs but also gross revenue may be controlled to some extent. This is shown in Figure 48, which represents the break-even chart of a hypothetical long-distance natural gas pipe-line. The investment required for this line, which was assumed to have a length of 500 miles, an outside diameter of 24 inches, and a maximum daily capacity of 145 million cubic feet per day, was estimated to be $15,450,000. It was also assumed that gas could be purchased by the pipe-line for resale at a price of 5¢ per MCF and that gas could be sold at the terminal of the pipe-line at prices varying from 22¢ to 8¢ per MCF, the highest price gas being sold first, gas of the next highest price next, and so on. The following tabulation is based on these and other data.

Pipe-line annual use factor in percent	20	50	70	90
Per year in thousands of dollars:				
Gross revenue	2,320.6	4,693.9	5,957.7	7,014.5
Cost of gas for resale	527	1,317.5	1,844.5	2,371.5
Cost of compressing station fuel	46.8	117.1	163.9	210.8
Compressing station operating costs	252.8	252.8	252.8	252.8
Pipe-line operating costs	185	185	185	185
Fixed management and overhead costs	571.6	571.6	571.6	571.6
Return on investment (8 percent)	1,236.	1,236.	1,236.	1,236.
Amortization (6 percent, 15 years)	664.4	664.4	664.4	664.4
All costs	3,483.6	4,344.4	4,918.2	5,492.1
Profit or loss	1,163.0 (*loss*)	349.5	1,039.5	1,522.4

The Break-Even Chart (Figure 48) representing the above tabulation graphically indicates that the break-even point of the pipe-line occurs at about 43 percent of capacity. If the return on the investment is lowered —in other words, if the pipe-line can be financed at lower interest and dividend rates than an over-all return on the investment of 8 percent—

the break-even point becomes a lower percentage of the capacity. An increase in the price of gas sold at the terminal of the pipe-line will also lower the break-even point. The effect of these changes is indicated in Figure 48.

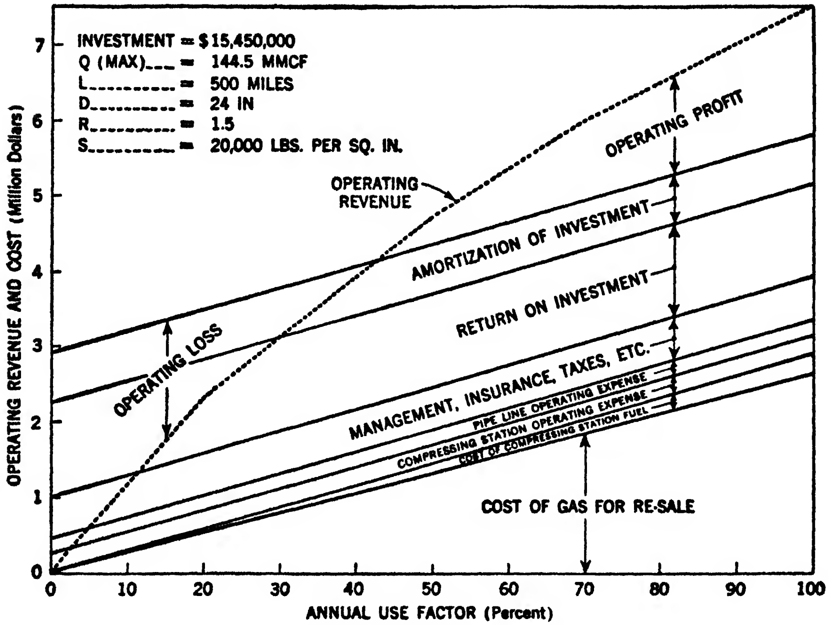

Figure 48. The Break-even Chart of a Natural Gas Pipe Line

The break-even chart can, of course, also be applied when additional investments are made. For example, additional compressing station or looping may be necessary to increase the capacity of a pipe-line. A graphical comparison of increased revenues but also increased costs with revenues and costs before additional investments will be very valuable.

There are, as stated above, many other applications of the break-even chart. The above examples illustrate only the usefulness of the chart as an executive tool in the natural gas industry.

2. THE BREAK-EVEN CHART APPLIED TO A SILK MILL

In some cases, as previously stated, the straight-line relationship between certain types of expenses to output does not hold throughout the entire range of output. This is sometimes the case in the process industries in which certain types of cost vary directly with output from about 30 percent to 100 percent of capacity. Below 30 percent capacity, due to the nature of these costs, there is a downward trend. Such a case is reported in the following example from practice.

Mr. H. R. Mallory, of Cheney Brothers, South Manchester, Connecticut, in *Mechanical Engineering*, August, 1933, presents an example of the use of the break-even chart in the silk industry. He states in part as follows:

> It has been demonstrated in actual practice that it is possible to control these expenses * in direct proportion to plant activity (allowance being made for fluctuations in raw-material market prices). Various ways and means of doing this are used in the items of variable manufacturing overhead in the same manner; therefore some method must be devised, that will enable us to set limits of variation from the straight-line relationship, so it may be used for budget and control purposes. Deviations from the straight-line relationship for indirect expenses are caused by the necessity of running elevators, oiling shaftings, repairing belts, main motors, switches, etc., even though some of the machines which are serviced by them may be idle due to reduced volume of business.
>
> Mill Allowances for Control of Departmental Room Variable Expense
>
> Let us assume that the plant is divided into many departments or areas of expense control and that over each department is a foreman who controls, in addition to direct labor and direct material, the following items of expense: (a) indirect labor, (b) power, (c) indirect supplies, (d) machine repairs, and (e) miscellaneous expense.
>
> If we consider one room in which there are, for instance, 400 machines, it is possible to establish with accuracy, after careful study, the amount of indirect labor required when all of the machines are in operation. Similarly, it is possible to establish the required amount of expense for power, indirect supplies, machine repairs, and miscellaneous expense. The readings in dollars at 100 percent activity in Figure 49 represents the controllable indirect variable expenses required when the room is running at full activity. The scale of the chart has been set so as to provide the readings in terms of expense per week, instead of annual expense.
>
> The readings in Figure 49 should be made from the base line up to the line of expense in question. In the preceding charts, the expenses were added, one to the other. On either form of chart, a straight line, passing through O and representing a variable expense, is directly proportional to plant activity or income from sales.
>
> The items of indirect expense listed in Figure 49 should, according to the sales dollar, vary in direct proportion to activity, but physically it is impossible to make them do so, and therefore limits to the amount of variation from the theoretical ideal should be established. At Cheney Brothers, South Manchester, Connecticut, budgets for 100, 80, 60, 40, 20, and 0 percent activity were established for each department in the plant. By a careful comparison of actual expenses with the budgeted allowances and by charting the amount of actual expense for the various departments over a period of about two years, it became possible to

* Direct materials and direct labor.

establish maximum and minimum limits of variation from the straight-line relationship for the variable indirect expenses. It is obvious that the minimum variation from the directly proportional straight line for various degrees of activity is zero, so that the straight line itself may represent the minimum. Empirically, it has become possible to state that the maximum is the parabola expressed by the equation $Y^2 = KX$ (see Figure 49).

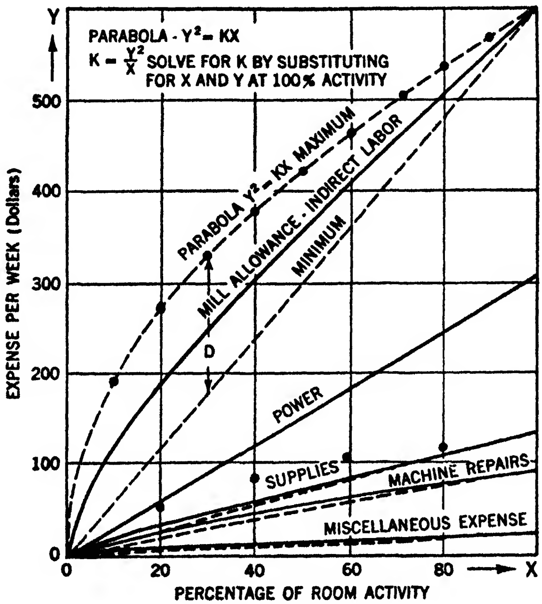

Figure 49. Mill Allowances for Control of Departmental Room Variable Expense *

Indirect labor	- K = 3600	Mill allowance = 40% of D
Indirect supplies	- K = 169	Mill allowance = 25% of D
Machine repairs	- K = 81	Mill allowance = 25% of D
Misc. expense	- K = 4	Mill allowance = 25% of D

In Figure 49, the distance between the minimum straight line and the maximum parabola is called D. Somewhere between the minimum and maximum is the permissible allowed variation over and above the straight line. This permissible allowed variation is expressed in terms of percentages of D. For instance, the allowed variation from the minimum theoretical straight line for indirect labor is 40 percent of D, and a curve plotted through points of 40 percent of D for different percentages of activity represents the expense control curve for this item. For any given

* Variable power mill allowance is a straight line. (Fixed expense of power plants is included in production department fixed charge.)

weekly activity, the ordinate to the expense control curve represents the standard allowed expense with which the actual for the week is compared. Each foreman is thus furnished with expense reports each week for the item of variable indirect expense he controls, and he must keep his expenses within predetermined authorized variations that, as will be shown later, have been used to modify the break-even chart. His report also shows comparisons of his actual and allowed direct expenses.

It has been possible to apply the standard allowance, 25 percent of D, for machine repairs, indirect supplies, and miscellaneous expense in practically all production departments. The mill allowance for indirect labor, however, while set at 40 percent of D for most departments, varies according to local conditions and may be 60 percent of D in some cases, but in no case is it allowed to exceed 100 percent of D, which is the parabola. So far, it has not been possible to determine the allowed variation for variable power for the reason that individual departmental meters have not been available.

Variation of Fixed Expenses With Activity

There are certain items of "fixed expense" which Professor Rautenstrauch refers to as "constant total costs." According to the control required by the sales dollar, all expenses whether classified as fixed or variable should vary in direct proportion to plant activity. It may readily be seen that the amount of loss due to operating below the break-even point is entirely due to the so-called fixed expenses remaining constant for all degrees of activity. For this reason, it is necessary to examine the whole group of fixed expenses in order to determine which of them may in reality be "semi-fixed."

There are relatively few items of expense which cannot be made to vary to some extent with activity. There are some expenses, such as insurance, taxes, rentals of properties where properties are leased, etc., that will not vary with changes in activity and are actually fixed per annum. Such expenses as salaries, stores expense costing, central planning, etc., while in many instances classified as fixed, may actually be made to vary to some extent with activity. Figure 50 is a sample chart illustrating the way one of the so-called fixed expenses may be made to vary with activity. At first glance it may appear to be a very unsatisfactory method of treating salaried employees. On the other hand, it is important to realize the economic justification for the payment of salaries and to control them in a manner that is humane, as well as preserving the best nucleus of an organization for the future, for quite often a failure to plan a method of salary control results in the sudden discharge of a large number of salaried employees with no advance warning. This, however, is a subject in itself, and the chart serves to illustrate one method of controlling a so-called fixed expense and making it vary with activity.

The Modified Break-Even Chart

The conventional break-even chart is based on the assumption that all variable expense has a straight-line relationship or is in direct proportion

to activity, and that all the items classed as fixed expense remain as constant fixed expense for the whole range of plant activity.

In Figure 51 the conventional break-even chart is designated by the following lines:

a. Theoretical variable cost (dotted line).
b. Theoretical total cost (dotted line).
c. Income.

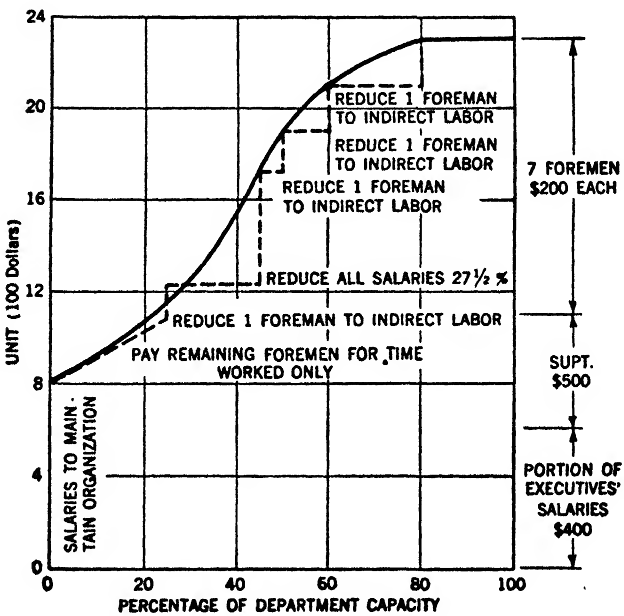

Figure 50. Control of Salaries of Production Department Showing Method of Control for Semi-fixed Expense. (Portion of Executive Salaries Assigned at Normal Operation is $400. Executive Salaries Reduced 27½ percent at 45 percent of activity.)

Since the variable indirect expense cannot be controlled in a direct straight-line relationship, the dollars of extra allowance for all items of such expense should be added together for a given percentage of activity and the extra allowance obtained should then be added to the theoretical variable cost. In Figure 51, the line of actual variable cost represents the result obtained.

Since some of the fixed expenses are in reality semi-fixed, they may be reduced as sales income and activity decrease. If the amounts authorized for items of fixed and semi-fixed expenses at a given activity are added

to the actual variable cost, the curve of actual total cost may be obtained.

The sales dollar used in this discussion to build up a practical working chart was established on the budget of expense and income made at 80 percent of plant capacity according to the conventional break-even chart. It is therefore obvious that the constant total cost of the conventional break-even chart is equal to the fixed and semi-fixed expense of the practical working chart at 80 percent activity. Since the "actual variable cost" is arrived at by adding an allowance to the straight line theoretical variable cost, it may readily be seen that, if the same budgeted amounts of fixed and semi-fixed expenses are added to (1) theoretical variable cost and (2) actual variable cost, the line of actual total cost will exceed the line of theoretical total cost at this point. Since the group of fixed and

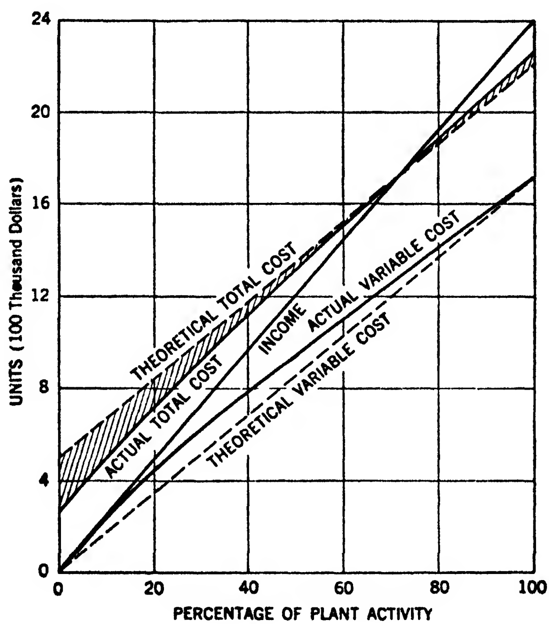

Figure 51. Comparison of Practical Working Chart with Theoretical Crossover Chart

semi-fixed expenses contains some semi-variable elements that may be made to decrease as activity decreases, these same semi-variable elements increase as activity increases, although not in direct proportion to activity. In Figure 51, the line of actual total cost is shown crossing the line of theoretical total cost at some point above the break-even point and gradually increasing as activity increases.

The cross-hatched area of Figure 51 represents the difference between the theoretical break-even chart and a practical working chart. For example:

At 90 percent activity, Professor Rautenstrauch's equation $p = X - (a + bx)$ gives a profit of \$130,000. In the equation

p = profit
a = fixed expense, or, as Professor Rautenstrauch designates it, "constant total costs"
$$b = \frac{\text{variable total costs}}{\text{corresponding sales}}$$

Based on a curve reading of the actual total cost and the income line in Figure 51, the profit at 90 percent activity is reduced approximately \$40,000 by the cross-hatched area, or instead of \$130,000, the profit is \$90,000.

Similarly, at 30 percent activity, the same equation indicates a loss of \$290,000.

Taking the difference between the income line and the actual total cost, there is a reduction in the loss, according to the cross-hatched area, of approximately \$95,000.

From this comparison, it may be seen that a literal use of the equation is likely to be misleading. This should not detract, however, from the value of the underlying theory expressed by the equations, for an understanding of the laws developed by Professor Rautenstrauch is essential in order properly to control any industry. Each business has its own peculiar economic characteristics and these should be developed and expressed in such a manner that the theoretical chart may be modified and put on a practical working basis.

The following special economic characteristics develop from a study of the curves:

(1) Direct labor and direct materials should vary in direct proportion to the percentage of plant capacity in a straight-line relationship.

(2) Variable overhead items should be made to vary with activity as closely as possible to the straight-line relationships.

In the silk industry, the variable overhead items may be controlled between the maximum and minimum limits shown in Figure 49, and according to the equation

$$Y = p(\sqrt{KX} - bX) + bX$$

where p is the percentage of D allowed. The curve for which this equation is the expression may be developed as outlined in the caption of Figure 49. It is felt that it is better to develop the curve in terms of percentage of D (see Figure 49) as there is a certain comparative value in saying that in one room the extra allowance for indirect labor is 40 percent of D, whereas in another it may be that 60 percent to 40 percent of D, if it can be accomplished, results in a saving. This is of great importance in a fashion industry, where activity is likely to fluctuate rapidly.

The value of p, or percentage of D, is a special economic characteristic for each room or burden center and for each class of variable indirect expense.

Whether the variable allowances described will apply to industries other than the silk industry is not definitely known, although the general characteristics of the expense class should be similar.

(3) The fixed expenses should be carefully examined in order to determine how and to what extent they may be made to vary with activity. Variable budgets should then be charted in order to determine the special economic characteristics of the items of fixed expense. When this has been done, the break-even chart may be modified to suit the particular business.

(4) The modified break-even chart constitutes a variable budget. As labor rates change and methods are improved, costs change, so that the chart should be revised at least twice a year at six-month intervals, and more frequently if necessary. During the period of time for which the chart is effective, the relationship between expense, income, and activity should be shown on the modified break-even chart, provided the average of selling prices remains the same. When the average of selling prices is changed, it is a simple matter to superimpose a new income line on the break-even chart.

(5) If it is assumed that the capital employed in the business shown in the accompanying charts is turned over twice a year, the percentage of profit on the capital employed will be double the percentage of profit on sales shown in the normal sales dollar; in other words, instead of a 3.3 percent profit, there is a 6.6 percent profit on the capital employed. It is apparent that the economic characteristics of the business shown on the accompanying charts are unsatisfactory, and therein lies the value of the break-even chart, for it discloses an inadequate profit at normal activity and a break-even point at a relatively high activity, which would mean that losses would occur with a slight drop in volume of sales. When it is stated that a 6.6 percent profit on the capital employed is an inadequate profit, it must be remembered that Federal taxes, interest on borrowed money, appropriations for betterments, provision of part of the surplus for pensions, etc., as well as preferred and common stock dividends, all have to come out of the profit referred to.

Importance of the Break-Even Chart

In closing, it is desired to point out that the special economic characteristics referred to apply to a single industrial organization that is a part of an industry. From the point of view of the individual organization, we have learned in recent years that the fixed quarterly, semiannual, or annual budget is not flexible enough to insure proper control of expense, or else that we are not endowed with sufficient prophetic vision to enable us to forecast the volume of business to be realized, on which to base the budget. Economic necessity has driven the individual organization to look for a more flexible medium of expense control. It is assumed that readers will appreciate that the major portion of the expenses subject to control consists of the wages of men. We are, therefore, forced to contribute to human misery by dropping men from the payroll when sales volume falls. Anything that may be done to eliminate fluctuations in

activity is, therefore, of decided benefit to the industrial worker. Since the laws developed by Professor Rautenstrauch may be applied to industry in the aggregate as well as to the individual organization, we may reasonably hope that an appreciation of these laws on the part of those who control the many organizations in an industry and on the part of those who finance industry may lead to more stable conditions of production.

QUESTION: If the author of this paper had included the variable expenses arising from the special conditions discussed under the heading Special Economic Characteristics in his calculations for determining the total controlled costs, would he not have had an approximate straight-line relation between total expense and income over the major operating range of his business? Examine Figure 49 and find the range of operations over which the total expenses closely follow an approximate straight-line trend.

3. MULTIPLE-PRICE POLICY IN THE RADIO MANUFACTURING INDUSTRY

Mr. Robert J. Levine,* in his master's essay entitled "A Study of the Small Radio Manufacturing Industry," makes the following observation.

> During the past ten years the writer, in watching the pattern of radio retail prices, has noticed a sales pattern which indicates that a rather unique price policy has been developed by some of the smaller companies in the industry. Radio pricing in this field is done two ways. The large companies set a price which satisfies a certain demand derived from their forecast of sales and then depend for sales on pressure advertising. Because of the cost of this heavy advertising, radios made by the larger companies usually cost more than those made by the smaller companies which do not have the means for following such a program. The smaller companies however have to compete on a price basis alone and are for this reason among others highly conscious of costs. The first step in marketing followed by the smaller companies is direct selling to the dealer and thus eliminating the jobber.
>
> The second step in offering a new line of radios is to offer their output in three price stages, which are an introductory stage, a quantity stage, and a closing-out stage. A pricing policy of this type gives rise to a new approach to the break-even chart.

Mr. Levine states that the dealer, knowing that the first price offered, which is the highest of the series, will later be reduced, makes an initial purchase sufficient to satisfy the first demand. After this demand declines, business is then stimulated by offer of the merchandise at a lower price. Toward the end of the season, the manufacturer practically dumps his remaining inventory on the market at cost. The break-even chart serves a very convenient use in setting up this multi-price policy. To illustrate the new method of pricing, the following example is used.

* Graduate student, Department of Industrial Engineering, Columbia University, 1948.

THE ONE-PRICE METHOD

A manufacturer proposes to produce 50,000 radios in the year to sell to the consumer for \$17.50 each. The manufacturer, under present practice, sells the dealer at 60 percent of consumer price or at \$10.50 each. The total sales, if all sets are sold at the above price, will amount to \$525,000. Using the data of seven leading radio manufacturers, a business of this proportion should experience total annual expenses of approximately \$30,-000 + 0.87% of sales. The break-even chart of the company when following the single-price policy should be as shown by the full lines in Figure 52. Under the single-price policy the manufacturer would break even at

$$Qp = \frac{a}{1 - b}$$

where $Q =$ quantity
$p =$ price per unit

then

$$Q \cdot 10.50 = \frac{30{,}000}{1 - 0.87}$$

when

$$Q = 22{,}000, \text{ approximately.}$$

The manufacturer's profit on the sale of the entire 50,000 radio sets would be

$$P = 50{,}000 \cdot 10.5\ (1 - 0.87) - \$30{,}000 = \$38{,}250$$

THE MULTI-PRICE METHOD

Under the multi-price method, the manufacturer sets a price which will result in a break-even point at say 20 percent of total output and which will also be the price at which say 30 percent of the total output is sold. In terms of radio sets, the break-even point would be at 10,000 sets and the first price would hold for 15,000 sets.

(1) *The First Price.* The price at which the manufacturer would break even at 10,000 sets is found as follows.

By calculation

The break-even chart of Figure 52 is laid out such that the variable total expenses for 50,000 radio sets is 87 percent of \$525,000 = \$456,750 or \$9.135 per set. For 10,000 sets, the total expenses of manufacture would be

$$\$30{,}000 + \$9.135\ (10{,}000) \text{ or } \$121{,}350$$

If the business is to break even at 10,000 sets, the price per set must be \$12.135. This means that if the consumer's price is based on a mark-up of 40 percent, the consumer's price will be $\dfrac{\$12.135}{.60} = \$20.22$, say \$20.25.

The sales of the manufacturer for the first 15,000 sets (30 percent of output) will be 12.135 · 15,000 = \$182,025 and his profits on these sales will be

$$P = 15{,}000\ (\$12.135 - \$9.135) - \$30{,}000 = \$15{,}000$$

By chart

The above information may be quickly derived from the data obtained from Figure 52 through drawing the sales line O-C such that it crosses the expense line at 10,000 sets and terminates at C at 15,000 sets. The chart, of course, must be large in angle so that the dollar sales required to break even ($121,350) and the total sales value of the 15,000 sets ($182,025) can be read from the chart with close approximation.

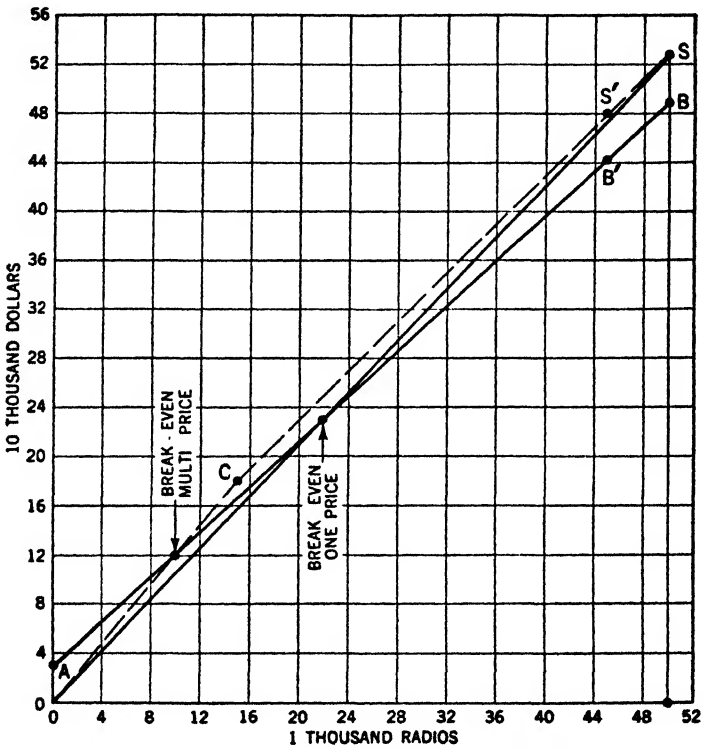

Figure 52. The Break-even Chart for a Radio Manufacturing Company with Multi-pricing

(2) *The Second Price.* The second pricing is determined as follows. Depending on the market, particularly how well the public is buying in the different price ranges, it may be decided that the next 30,000 sets which would bring the total sales up to 90 percent of output, are to be sold at a price which will yield a profit for 90 percent of the output equal to what the profit would have been for 100 percent output at a sales price of $10.50 as under the one price system.

By calculation

The cost of 45,000 sets is

$$c = \$30{,}000 + (\$9.135 \cdot 45{,}000) = \$441{,}075$$

The profit to be realized is $38,250 as determined above. Hence the cumulative sales income for the 15,000 sets sold at the first price, and the 30,000 sets now to be sold at a price to be determined, is

$$\$441{,}075 + \$38{,}250 = \$479{,}325$$

But the first lot of 15,000 was sold for $182,025 as determined above and therefore the second lot of 30,000 sets is to be sold for

$$\$479{,}325 - \$182{,}025 = \$297{,}300$$

or for $9.91 per set. On the basis of a 40 percent mark-up, the consumer price would be $16.50.

By chart

An ordinate is erected at 45 on the base. Where it cuts the expense trend line A-B, mark that point B′. Lay off B′-S′ = B-S and join C and S′ to show the sales line for the second lot (30,000 sets). The vertical distance of horizontals through C and through S′ divided by 30,000 determines the price to the dealer of the second lot.

(3) *The Third Price.* The remaining 5,000 sets are then dumped on the market at a price to the dealer equal to the unit cost of the whole lot of 50,000 sets. The price to the dealer will then be

$$\frac{30{,}000 + (50{,}000 \cdot \$9.135)}{50{,}000}$$

or $9.735 per set.

The consumer's price will be $\dfrac{\$9.735}{0.60} = \$16{,}225$, say $16.25

The line S′-S complete this chart.

In summary then: Under the one-price system, the price to the dealer is $10.50 per set, while under the multi-price system the first lot of 15,000 sets is sold for $12.135, the second lot of 30,000 sets is sold for $9.91 per set, and the remainder is sold for cost at $9.735 per set. This practice is not looked upon with favor by the large manufacturer, nor by the majority of the dealers, because as one prominent member of the radio industry recently stated at a meeting of the National Electrical Retailers Association:

> Dealers expect from manufacturers price stability to make their inventories safe investments and prefer to deal with producers who follow a sound and equitable program of dealer franchising.

PART II

INDUSTRIAL COST CHARACTERISTICS

INTRODUCTION

THE ECONOMIC CHARACTERistics of a business as a whole, which was developed in Part I, may be likened to the functional characteristics of a machine or the structural characteristics of a bridge or building. The machine designer in developing a new machine proceeds to lay out the whole mechanism according to the functions it must perform. The whole arrangement of the many parts is laid out according to a general pattern which experience has shown will accomplish the over-all requirements of the intended operations. The completed machine when tested is found to have certain characteristics of performance which, if the design is well conceived, will closely parallel the results which the designer sought to attain. But after the general lay-out with respect to functional operation has been made, the designer must then proceed to determine for each part the proportions needed to provide adequate strength and stiffness. Unless the parts are properly proportioned the machine will not work, even though the general pattern of its lay-out

may be functionally sound. If also the structural designer may conceive of a bridge which is functionally adapted to its intended use but if its members are not correctly proportioned, the bridge will fail. So also in business enterprise, the general character of its financial and operational organization may be well conceived, but if the methods for finding and estimating detailed operational costs are faulty, the enterprise may fail. Functionally, the business may be well conceived as to markets for its products, methods of production, sources of raw materials, and financial structure, but if the instruments on which it relies to guide its course are faulty and do not reflect correctly the details of its economic performance the business is in danger.

Accordingly, while it is necessary that the businessman understand the over-all operating characteristics of the business he is managing, he must also understand fully the details from which the over-all facts are derived or else he will not be in a position to make the adjustments necessary to adapt the business to the ever-changing economic environment of the modern world.

Part II of this book is therefore devoted to an examination of the principles underlying the detailed costs of production and of the methods which experience has proved are best adapted to embodying these principles in practical operative procedures. To develop the principles and methods for determining the cost of the product as it is built up from raw materials through the many steps of production to delivery to the customer is the primary objective of this part of the book. Another objective is the development of the principles and methods of the many kinds of cost calculations that are needed for making the innumerable decisions demanded of management at all levels of operation.

VIII

BASIC CALCULATIONS IN THE USE OF MONEY

ENGINEERS AND INDUSTRIALists use machinery and equipment to create goods and services. The machinery and equipment used are recorded in books of account as "worth" specific amounts of money, and the goods and services produced are stated to have "cost" this or that amount of money. When new and improved machinery is offered the manufacturer, he wants to know whether it will pay to buy it at the price offered. The price paid for machinery and equipment, and its relation to the costs of goods and services produced by their use, poses a problem in the investment of money.

More specifically, the problem of investment in machinery and equipment is a problem in alternatives; will it pay to buy A at Price X, or B at Price Y or C at Price Z *for use under specific circumstances.* The "use under specific circumstances" is a very important part of the problem of investment to which more attention will be given as our study proceeds.

1. THE EARNING POTENTIAL OF MONEY

Before the question, will it pay, can be answered, it will be necessary to acquire some basic concepts about money, particularly about what may be termed its earning potential and its time value. It is frequently stated that money is a medium of exchange. When money is paid in exchange for materials, machinery or services, the amounts so paid are recorded in books of account and become known as the "book values" of the items purchased.

Money not only gives one the capacity to possess or to acquire something when used as a medium of exchange but it also has the capacity to earn, that is, it has a rental value. The rental value of money is expressed in terms of interest rates.

Money is rented or loaned at rates of interest which depend on the state of the money market and on other considerations such as the allowable legal rates which vary in the different States of the Union. Money is rented or loaned to the Government, or to a corporation, when one buys their bonds and notes. Using money to buy bonds and notes or to deposit in savings accounts in banks for the purpose of earning more money are well-known procedures by which investors endeavor to increase their money.

The earning potential of money has an important bearing on the problem of investing in a new Machine A to use in a manufacturing process and to replace a present Machine B used for the same purpose. If it is determined, for example, that by using Machine A to replace Machine B an annual saving of $1,000 is probable, the "pay-off" is not only in the annual savings of $1,000 per year but also in *the earning power of each annual saving* throughout the estimated useful life of the machine. If, for example, the useful life of the machine is estimated to be 10 years, the total savings incurred in its use are not only $1,000 for each of its 10 years of use, or $10,000 in total, but there are in addition the potential earnings in the form of interest (compounded annually) for 9 years on the first year's savings, for 8 years on the second year's savings, for one year on the ninth year's savings. If the interest rate used is 4 percent, then the earnings on the annual savings will, in this example, amount to $2,007. These earnings on the savings, together with the savings themselves, will therefore total $12,007. The thoughtful student, examining critically the estimate made above, will ask himself: How is it determined that the useful life of a machine is 10 years or any other number of years? Why is 4 percent interest used in the example, and will it probably

be the same for the estimated 10 years? Does a manufacturer really put such savings as determined in this case at interest or are they intermingled with all the assets and used in the business? Upon what assumptions are the savings of $1,000 per year made? What is the probable error of estimate?

These are important questions, and some satisfactory answer must be given if economic calculations of the above nature are to make sense. With these questions held in abeyance for the time being and, in order to consider them more fully in relation to other problems in engineering economics, the basic formulas used in making calculations of the above nature will now be reviewed.

2. SIMPLE INTEREST

This is the form of interest which applies to the original sum or principal only. Thus, if

$$P = \text{the principal or sum of interest}$$
$$R = \text{the rate of interest (usually annual)}$$

then the total amount of the interest at the end of the first stated time period (usually one year) is PR, at the end of the second period is 2 PR, and at the end of the Nth period is NPR. Thus, if \$100 is put at 6 percent annual simple interest, it will have a value after 6 years of

$$\$100 + 6\,(\$100 \cdot 0.06) = \$136.$$

The value of a principal sum at interest after a period of time is known as the *amount* and may be designated by A. Therefore, if

$$P = \text{the principal (the original sum put at interest)}$$
$$R = \text{the rate of interest (annual)}$$
$$N = \text{the number of years}$$
$$A = \text{the amount (principal plus interest)}$$
$$I_s = \text{the interest,}$$

then

$$A = P\,(1 + NR)$$
$$I_s = PNR$$

The following problems illustrate the use of these formulas.

Problem 1. What will be the amount, that is, the value of \$150, after 3 years at 6 percent simple interest?

$$A = \$150\,(1 + 3 \cdot 0.06)$$
$$= \$150 \cdot 1.18 = \$177$$

Problem 2. What sum (principal) invested at 5 percent simple interest will amount to \$600 in 4 years?

$$\$600 = P(1 + 4 \cdot 0.05)$$
$$P = \frac{\$600}{1.2} = \$500$$

Problem 3. What is the simple interest on \$700 for 4 years at 6 percent?

$$I_s = \$700 \cdot 4 \cdot 0.06$$
$$= \$168$$

If interest payments are due and paid annually, then only simple interest can apply.

3. COMPOUND INTEREST

When a sum of money is put at interest, which is payable at stated periods, and the interest when due is added to the principal and also bears interest, the sum is said to be at compound interest. The total amount accumulated after a given time is termed the *compounded amount.* The difference between the compounded amount and the original sum or principal is the compound interest. The number of times a year that interest is converted into principal is called the *frequency.* If interest is compounded quarterly, the frequency is 4; if annually, 1.

Let: P = the principal or original sum.
R = the annual rate of interest.
N = the number of years.
M = the frequency.
A = the compounded amount (P + accumulated interest)
I_c = the amount of compound interest accumulated.

Accordingly, if $M = 1$ (that is, interest compounded annually) then, at the end of the first year

$$A_1 = P(1 + R)$$

at the end of the second year

$$A_2 = P(1 + R)\ (1 + R)$$

at the end of the third year

$$A_3 = P(1 + R)(1 + R)(1 + R)$$

at the end of N years

$$A = P(1 + R)^N$$

The term $(1 + R)^N$ is the *compounded amount factor.* Values of this factor for different values of N and R are given in Table XXXVII, page 219.

If M is any other amount, say, 4, for example, A is determined by multiplying N by 4 and dividing R by 4. Accordingly, the compounded amount of $1,000 at 6 percent, componded quarterly after 4 years, is

$$A = \$1{,}000(1 + 0.015)^{16}$$

The amount of compound interest (I_c) derived from the principal P after N years is the compounded amount A less the principal P. That is,

$$\begin{aligned} I_c &= A - P \\ &= P(1 + R)^N - P \\ &= P[(1 + R)^N - 1] \end{aligned}$$

Figure 53 illustrates some typical cases of compound interest accumulations.

4. THE PRESENT WORTH, AT COMPOUND INTEREST, OF A FUTURE SUM OF MONEY

If a sum of money is to be paid at a distant date as part of a consideration in a transaction, and it is desired to settle all accounts at present so that all parties are cleared of future obligations, the question arises: What is the present worth of the sum to be paid at the distant date? The answer to this question is the same as the answer to the question: What sum put at compound interest (current rates) now will amount to X (the amount to be paid in the future) in N years (the future date)?

The present worth of such a sum is

$$P = \left[A \frac{1}{(1 + R)^N} \right]$$

The term $\dfrac{1}{(1 + R)^N}$ is known as the *present worth factor.* Values of this factor for different values of N and R are given in Table XXXVIII, page 220.

For example, if \$1,000 is to be paid 3 years from today, and the rate of interest is 6 percent, its present worth is

$$
\begin{aligned}
P &= \$1{,}000\ [0.8396] \\
&= \$839.60
\end{aligned}
$$

In other words, if \$839.60 is put at 6 percent interest, compounded annually, the compounded amount in 3 years would be \$1,000.

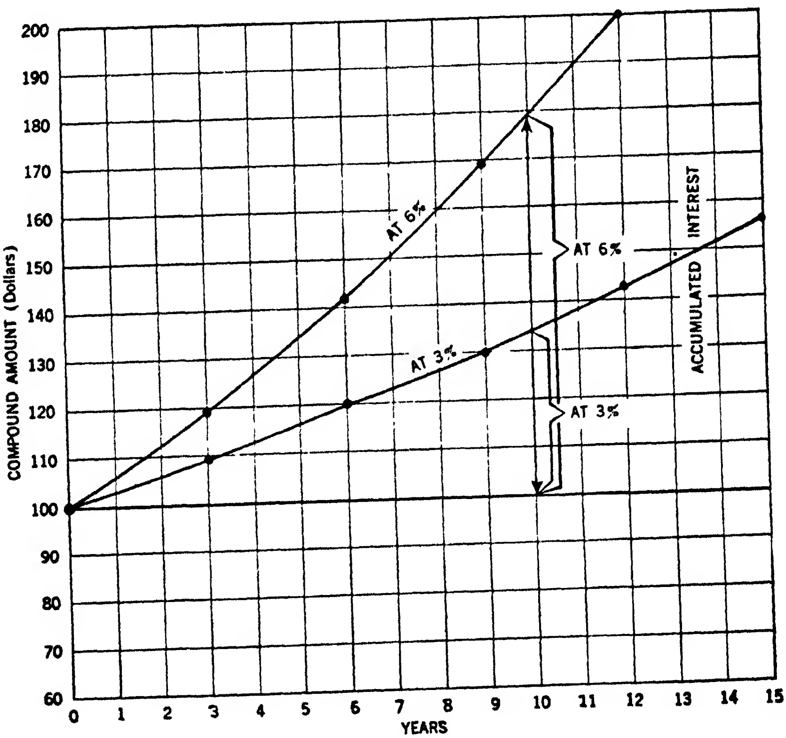

Figure 53. A Graph of Compound Interest Accumulation

The present worth of an anticipated future sum is not only conditioned by the number of years (N) to elapse before realization but also on the rate of interest chosen in estimating the present worth. The rate of interest chosen is determined by the nature of the risk in the contract for realization or future delivery of the anticipated sum.

If, for example, a young man 16 years of age should be heir to a legacy in the form of securities valued at current market prices at \$100,000, and he wishes to sell this legacy, the following questions arise:

a. In the event of his death before the age of 21 years, is the legacy cancelled?

b. What will the legacy probably amount to if earnings on the securities are accumulated up to time of delivery?

c. What are the chances that the securities may decline in value in the next five years, or become worthless due to the failure of the business underlying the securities?

In consideration of any of these or other possibilities, the prospective purchaser will weigh all the chances and decide what rate of interest will in his opinion justify the purchase. Assuming, for example, that the legacy at maturity is estimated by the prospective purchaser to have a probable worth of \$100,000 *based on certain assumptions,* he may believe that the risk is fairly good and determine the present worth on the basis of 6 percent. In this event, he will offer to purchase at

$$\begin{aligned} P &= \$100{,}000 \cdot (.7473) \\ &= \$74{,}730 \end{aligned}$$

If, however, he believes the risk is not so good, he may estimate the present worth on the basis of 8 percent and accordingly offer to purchase at

$$\begin{aligned} P &= \$100{,}000 \cdot (.6806) \\ &= \$68{,}060 \end{aligned}$$

This example and also for the case of a 10-year future expectancy are illustrated in Figure 54.

5. SINKING-FUND DEPOSITS

It is frequently provided in financial arrangements that the borrower must deposit annually a certain sum of money, such that the total of the equal annual deposits at compound interest will amount to the sum to be repaid at the due date.

Let D = the sum of money to be deposited annually * in the sinking fund and compounded annually.

A_F = the amount of money to be repaid or the amount of money to be in the sinking fund at the due date.

N = the number of years during which the sinking fund is to be accumulated. (The number of times the sum of money D is put in the fund.)

R = the rate of interest (annual).

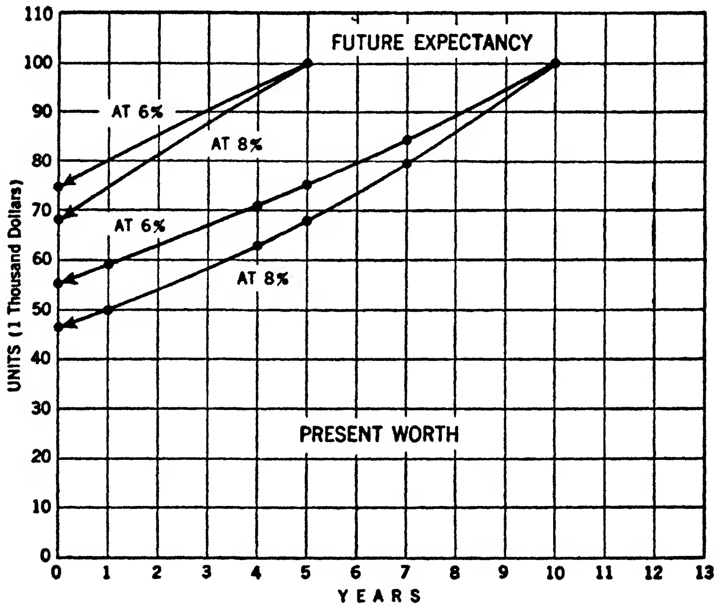

Figure 54. A Graph of Present Worth

Accordingly,

$$A_F = D\,(1 + R)^{N-1} + D\,(1 + R)^{N-2} \ldots + D$$

from which is derived

$$D = A_F \frac{R}{(1 + R)^N - 1}$$

The term $\dfrac{R}{(1 + R)^N - 1}$ is known as *the sinking-fund factor.* Values

* The first deposit of the series is put in the fund at the end of the first year. It will be compounded annually for (N − 1) years. The last deposit is put in at the due date.

of the sinking-fund factor for different values of N and R are given in Table XXXIX, page 221.

Example. What annual sinking-fund deposits at 6 percent compound interest are required to provide a fund to redeem a debt of $10,000 maturing ten years from date?

Solution. D = 10,000(0.07587) = $758.70

The graph of the above problem and its solution is given in Figure 55. For purposes of comparison, there is also shown in Figure 55 the

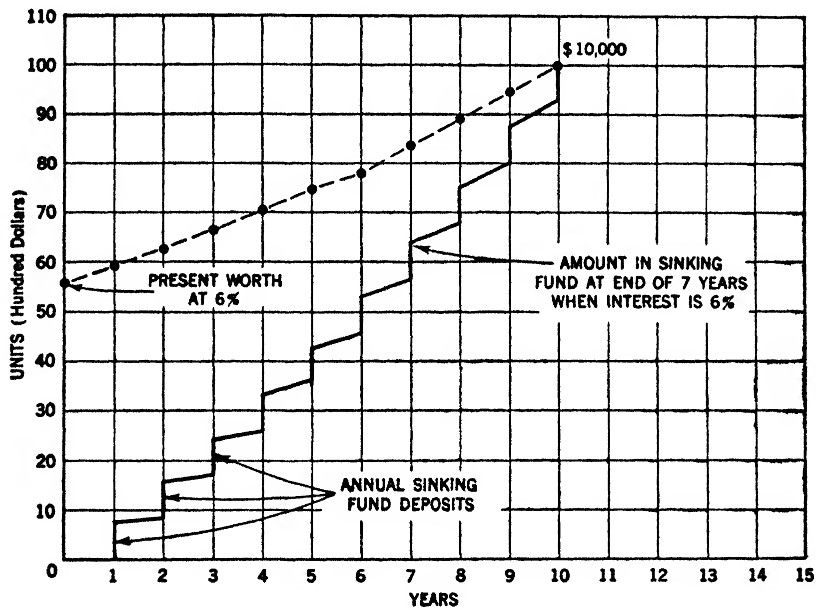

Figure 55. A Graph of Sinking Fund Accumulations with Present Worth of Final Fund

present worth of $10,000 at 10 years hence on the basis of 6 percent annually compounded interest. This present worth ($5,584) is that sum of money which, if deposited at 6 percent annual compound interest, would amount to $10,000 after 10 years. These comparisons (present worth and annual deposits) are important for the visualization of some aspects of investment which are about to be decribed.

6. CAPITAL RECOVERY

a. Deposits may be required to be made annually in a sinking fund to redeem a loan which bears interest compounded annually. A lender may be willing to risk a loan of, say, \$100,000, to be repaid with compound interest at the end of 10 years, but because of some speculative features of the undertaking, for which the money is to be used, the lender demands interest on his money at the rate of 10 percent compounded annually. He, furthermore, as additional protection, requires the borrower to deposit annually in a trust fund in a savings bank, that sum of money which at 4 percent compound interest will in 10 years equal the \$100,000 plus interest *at 10 percent* compounded annually. Under these circumstances the amount of money to be accumulated in the trust fund (sinking fund) is the compounded amount of \$100,000 for 10 years *at 10 percent*. That is

$$A_F \text{ must equal } P\,(1+R)^N$$

Therefore:

$$D \text{ must equal } P\,(1+R)^N \cdot \frac{R'}{(1+R')^N - 1}$$

in which
$P = \$100{,}000$
$R = 10$ percent
$R' = 4$ percent
$N = 10$ years

Since $(1+R)^N =$ the compounded amount factor

and $\dfrac{R'}{(1+R')^N - 1} =$ the sinking-fund factor it appears that

capital recovery in N years at interest R compounded annually to be redeemed through equal annual deposits in a sinking fund which is compounded annually at R′ percent, is

$$D = P\,(\text{compounded amount factor}) \cdot (\text{sinking fund factor})$$

evaluated in terms of the interest rates applying to each factor. Thus, in the example cited above:

$$D = \$100{,}000\,(2.594) \cdot (0.08329) = \$21{,}605.43$$

b. In case the interest rate applying to the sinking fund is equal to the interest rate applying to the loan, and that interest rate is R,

Then,

$$D = P\,(1+R)^N\left[\frac{R}{(1+R)^N-1}\right]$$

$$= P\left[R+\frac{R}{(1+R)^N-1}\right]$$

$$= P\ (\text{capital recovery factor})$$

The capital recovery factor = R + sinking-fund factor. The reciprocal of the capital recovery factor is known as the Inwood Factor. Accordingly,

$$D \cdot (\text{Inwood Factor}) = P$$

c. There are situations in which the investor demands equal annual cash payments (PR), for use in meeting living expenses, plus equal annual deposits (D) in a sinking fund compounded annually at the interest rate (R′) to provide for capital recovery after a specified number of years. The borrower under the circumstances must meet an annual obligation of

$$PR + P\left[\frac{R'}{(1+R')^N-1}\right]$$

or

$$P\left[R+\frac{R'}{(1+R')^N-1}\right]$$

or $$P \cdot (\text{simple interest} + \text{sinking fund factor})$$

If, therefore, $100,000 is borrowed for 10 years with the provision that the lender is to be paid $6,000 annually and a sinking-fund is to be set up bearing 4 percent compound interest, which fund will amount to $100,000 in 10 years, the equal annual deposits in the fund will be

$$D = \$100{,}000\,(0.08329)$$
$$= \$8{,}329$$

The annual obligation the borrower must meet will be

$$\$6{,}000 + \$8{,}329 = \$14{,}329$$

d. If the borrower should demand not only equal annual cash payments (PR) but also that his capital (P) be returned in 10 years at compound interest (R″) to be provided through a sinking fund, the

annual deposits in which shall be compounded annually at the interest rate (R′), then such annual deposits are

$$D = P(1 + R'')^N \left[\frac{R'}{(1 + R')^N - 1} \right]$$

and the annual obligations to be met by the borrower become

$$PR + P(1 + R'')^N \left[\frac{R'}{(1 + R')^N - 1} \right]$$

7. EQUIVALENCE

Money may be borrowed upon different terms of repayment of the loan with interest. The usual methods are:

A. To pay the entire loan at the end of the period, but pay the amount of interest annually or semiannually as specified.

B. Reduce the principal by equal amounts each year and pay the amount of interest on the remaining balance.

C. Pay equal amounts each year such that the total annual payments will equal the principal plus interest on remaining balances for the entire period of the loan. Part of the equal amounts paid each year will be credited to the reduction of the loan after the appropriate interest on the remaining balance has been deducted.

D. Pay the entire loan, with annual compound interest, at the end of the period.

These four methods are equivalent in respect of the rate of interest paid on the actual sum of money in possession of the borrower at all times. They each pay the same rate of interest. The results of operating under each of these four plans of repayment of a loan of $10,000 at 6 percent for a period of 10 years are shown in the following table. But they are not equivalent in respect of the sum of the present worth of all the year-end payments if the present worth is calculated at an interest rate differing from that of the loan. For example, the sum of the year-end payments in each case is the present worth of the total of future payments, when the interest rate is zero. Thus, under Plan A the present worths of the total of year-end payments at 0 interest is $16,000; Plan B $13,300; Plan C $13,587; and Plan D $17,908. If the interest rate should be 6 percent, for example, the sum of the present worths of the year-end payments would each be $10,000. If the interest rate should be 4 percent, they would be: Plan A $11,620; Plan B $10,940; Plan C $11,020; and Plan D $12,100 (see Table XXXVI).

TABLE XXXVI

FOUR PLANS FOR THE REPAYMENT OF A LOAN OF $10,000, AT 6 PERCENT FOR 10 YEARS

Plan	End of Year	Year-end Payments	Remaining Balances
	1	$ 600	$10,000
	2	600	10,000
	3	600	10,000
	4	600	10,000
A	5	600	10,000
	6	600	10,000
	7	600	10,000
	8	600	10,000
	9	600	10,000
	10	10,600	0
	1	$ 1,600	$ 9,000
	2	1,540	8,000
	3	1,480	7,000
	4	1,420	6,000
B	5	1,360	5,000
	6	1,300	4,000
	7	1,240	3,000
	8	1,180	2,000
	9	1,120	1,000
	10	1,060	0
	1	$ 1,358.68	$ 9,241.32
	2	1,358.68	8,437.12
	3	1,358.68	7,584.67
	4	1,358.68	6,681.07
C	5	1,358.68	5,723.25
	6	1,358.68	4,707.98
	7	1,358.68	3,631.77
	8	1,358.68	2,491.00
	9	1,358.68	1,281.78
	10	1,358.68	0.00
	1	$ 0	$10,600.00
	2	0	11,236.00
	3	0	11,910.16
	4	0	12,624.77
D	5	0	13,382.26
	6	0	14,185.20
	7	0	15,036.31
	8	0	15,938.49
	9	0	16,894.80
	10	17,908.49	0.00

Accordingly, if a loan is made at an interest R and any one of the four plans of repayment is adopted, the present worths at any other interest rate will not be equivalent.

The importance of this observation lies in the fact that the real interest rate paid on a loan depends on the plan of repayment and may be quite different from the declared interest rate. For example, if a bank loans a customer $1,000 for a period of 10 months at a declared interest rate of 6 percent, discounts the note at the beginning of the period, and requires the borrower to repay the loan in 10 equal payments of $100 each at the end of each month, we find that the following takes place. The bank takes $60 of the $1,000 and therefore gives the borrower only $940. At the end of the first month the borrower pays $100 and then has the use of only $840 during the second month. During the third month he has the use of only $740, and during the last month only $40. The average of the monthly sums in his possession is $490, for which he pays $60 *in advance.* If he should really pay interest at the rate of 6 per cent per year, which is one-half percent per month, at the end of each month *after the service had been rendered,* his interest costs would be at the average of $2.45 per month or $24.50 for the entire period of the loan. Thus the bank is really charging him more than twice as much as the declared interest rate. The determination of the exact interest paid in this case requires a rather involved computation and will not be given. The important matter to be observed is that the interest really paid may not always be that which is declared.

8. WHEN TO INCLUDE INTEREST

It is a widely accepted practice in estimating certain costs to include the interest on the investment as an item of cost whether or no any moneys are borrowed for the purpose of making the investment. That is, if one should pay $7,000 cash for a machine or purchase it on open account, in estimating the cost of production by the use of this tool, an interest charge of, say, 6 percent on the $7,000 is considered a proper charge as part of the annual cost to possess the machine. The writers feel that this practice is likely to lead to errors in judgment. It would appear that a fundamental purpose in cost accounting is to account for all the items of cost which are incurred. If, therefore, one borrows $7,000 to buy a machine and pays 6 percent on the money, naturally one of the costs of possessing the machine is $420 annually. If, however, one has $7,000 to invest, he may do one

of two things. He may lend it to someone through the purchase of a bond, for example, and receive 6 percent interest on his investment, or he may invest it in a piece of equipment he intends to use in production. In making his decisions he will estimate the probable returns on his investment in the equipment and its use in production as compared to the return he would get if he lent the money to another. If his estimates show that by purchasing the equipment and using it in production there is a probability of a return of 12 percent on his investment, he can then say that by investing in the machine there is a probability that he will receive 6 percent *more* on his investment than by lending it to another.

He must then determine the margin of hazard between the two situations and make his decision on the basis of whether or not the margin of hazard covers the probability of a 6 percent additional return.

If he does not have $7,000 and can borrow the money and then make the investment in the equipment for use in production he will have a probability of a return of 6 percent.

The writers feel that it should be fundamental in accounting practice, as stated above, to account only for actual situations as they exist and not for what they might be under other circumstances. Suppose that we carry the illustration still further. If a $7,000 machine is purchased for cash, no money is borrowed, and the machine is estimated to have a life of 7 years, then the products manufactured by the machine will be charged $1,000 per year for a period of 7 years, and in this way the investor sells his machine to his customers and recovers his original investment at the end of 7 years. Assume then that he goes out of business. He has his original investment of $7,000 and, in addition, has made a profit of 12 percent a year during the 7 years in which he has used his capital in this manner. Now, suppose that he added an item of 6 percent on the investment to the production cost and had charged his customers an additional $420 per year. At the end of 7 years, he would not only have recovered his original investment through the depreciation charge but also would have received, in addition, 7 · $420 or $2,940. He, therefore, would have made not only the 12 percent through the use of the machine in manufacturing but also an additional 6 percent, or a total of 18 percent in all. If he did not borrow the money from anyone, there is, therefore, no one to whom he has to pay 6 percent, and it is his own. Or suppose that he had estimated his costs to include interest and on this basis his books showed a profit of 6 percent on his investment. When he balances his

cash he finds he has made a gain of 12 percent, or twice as much as he estimated. Many accountants do not agree with this point of view, but the writers feel nevertheless that it is a correct one.

9. APPLICATIONS

a. *Investing in a New Machine*

When a businessman considers an investment he examines the matter with reference to:

(1) The safety of capital, and
(2) The probable return or earnings.

He makes the investment with the prospect of getting his money back at some future date plus interest. If he buys stocks or bonds for investment he deals with an investment banker or a broker who acquaints him with the data relating to the enterprise underlying the securities, from which he forms his judgment. The manufacturer is also an investor and when he considers buying a new and improved type of machine he also wants to know how safe is his capital and what the probable returns or earnings may be. He also wants eventually to get his money back with satisfactory interest. His process of reasoning in making such purchases is about as follows. Let us assume that by the use of his present processes a given set of operations in his factory costs, say, $10,000 per year at current rates of production. He is offered a machine or group of machines which, estimates show, will lower the cost of production, including depreciation in 5 years, at the current rate of output by $2,000 per year. The machinery is offered at the price of $20,000. Is it a good buy *at the price offered*?

The first question to be answered is: How soon should the capital be recovered with interest? Business conditions and the state of the arts, both with reference to the products made and the probability of even better machinery being available within the next few years, often prompt the manufacturer to want to recover his investment with interest, say, in five years, even though the estimated *mechanical* usefulness of the machine may be 10 or more years. Let us assume then that the *economic* usefulness of the machine is accepted as 5 years. As an investment, then, the problem begins to take the form of the sinking fund problem presented above. Let us assume that the annual savings of $2,000 are considered as sinking-fund deposits and that they are put at interest at current rates, say 4 percent, compounded annually.

It appears, therefore, that the accumulated amount in the fund at the end of 5 years will be

$$A_F = (\$2{,}000 \div 0.18463) = \$10{,}832$$

The compounded amount of $20,000 (the investment in the machine), in 5 years at 8 percent interest (assuming that 8 percent is indicative of the risk), is $20,000 · 1.469 = $29,380, from which it is found that the accumulated interest on the investment is $9,380. Since one fifth of the investment in the machine is recovered each year through depreciation, the accumulated interest on the average annual investment is much less. For example:

The $20,000 invested in the machine is returned through adding $4,000 each year to the cost of the products made by the machine. Thus, at the end of the first year, only $16,000 remains as unrecovered investment, at the end of the second year only $12,000 remains as unrecovered investment, etc., etc. Accordingly, during the five-year life of the machine the average investment is $20,000 for one year; $16,000 for one year; $12,000 for one year; $8,000 for one year and $4,000 for one year, or an average of $12,000 for 5 years. If 8 percent interest is indicative of the risk, then the return on the average annual investment should be .08 · $12,000 = $960.00 per year or 5 · 960 = $4,800 for 5 years.

Since the annual savings from the use of the new machinery will, in 5 years at 4 percent compound interest, amount to $10,832, it appears that the investment of $20,000 in the new machinery will yield a return greater than 8 percent, and therefore the investment is justified since it more than meets the risk demand prescribed.

But how about the return of the capital invested? It will be noted above that the estimated savings of $2,000 per year were based on cost calculations which included depreciation as an item of cost. This means that the annual depreciation (which, if estimated on a straight time basis, is $4,000 per year) is charged into costs and as such is recovered in sales to the customers of the products of the machine. In a period of 5 years the $4,000 annual depreciation deposited in the depreciation reserve fund (but not at interest) will amount to $20,000. Accordingly, on the basis of the estimates of the costs of production in which the use of a new machine costing $20,000 will result in annual savings of $2,000 over present processes *after accounting for full depreciation* in 5 years, the investment may be considered satisfactory both as to the return of the original capital invested and also as to the interest on the investment.

b. *Investing in an Apartment House*

Should an investor be offered an apartment house at a specified price, how should he determine whether or not the purchase price represents a good investment? His approach to this problem should be as follows. First, he should determine the probable annual income from rentals, not only at present but for the future, say the next 25 years. At the same time he must determine the probability of real estate values in the neighborhood being maintained or even enhanced. Volumes may be written on both these problems (future income and future value) but we will not be concerned with these matters at this time. Second, he should determine the probable expenses for maintenance, repairs, upkeep, and other operating items and the annual depreciation. The difference between income and expense constitutes the probable annual net income for say 25 years.

If these annual net incomes (D) are deposited in a fund which is compounded at R percent for N years, then the amount accumulated in the fund after N years will be

$$A_F = D \cdot \left(\frac{1}{\text{sinking fund factor}}\right)$$

The present worth of this fund at an interest rate of R′ compounded annually will be

$$P = A_F \cdot (\text{present worth factor})$$

P then is the price at which the apartment house may be purchased as an investment to return an interest of R′ compounded annually for 25 years. The above relationships are illustrated in Figure 55.

To illustrate more fully the complete procedure in appraising the value of such properties for investment purposes, we reproduce below an article on this subject by Mr. Victor J. Free in the *Journal of the American Institute of Real Estate Appraisers,* January, 1938.

Great Lakes City,Ohio
December 11, 1937

Prairie Central Life Insurance Company
Osborne City, Iowa
Gentlemen:

Pursuant to your request of December 4, 1937, I have examined with care the property at 1115 South Jones Street in the city of Great Lakes, Ohio, and return herewith as of December 11, 1937, this estimate of market value: *Twenty-four thousand, five hundred dollars* ($24,500).

The purpose of this appraisal is that you may determine whether the renewal of a mortgage upon this ten-suite apartment property is advisable and for the best interest of your company. Therefore, I have considered market value only, leaving to your judgment the loan percentage of such value which you may consider safe and equitable.

I determined the market value to be the present worth of all the future benefits arising from ownership of this property—the present worth of a stream of net earnings during the reasonable remaining life of the building—to which I added the reversionary land value at the time the building has been exhausted.

In reaching this estimate of value I have relied upon the following:

(1) Neighborhood analysis and remaining expectant life.
(2) Rental levels of the neighborhood and their probable continuance.
(3) Economic and social forces in the city and neighborhood.
(4) A fair annual level of net income.
(5) The property residual procedure and the compound interest valuation premise, using the Inwood tables.
(6) An over-all capitalization rate with adjustment for land and building values, determined by comparison.

I thank you for this opportunity for serving you and trust that the report will be found satisfactory.

Yours very truly,
Richard Roe, M.A.I.
Appraiser

THE APPRAISAL

LEGAL DESCRIPTION:

Situated in the city of Great Lakes, Ohio, and known as sublot No. 120 in the Jones and Marshall Subdivision of Tract 4, Range 14, as shown in Volume 8, P. 112, of the records of Great Lakes County. Said sublot No. 120 is located on the northerly side of South Jones Street and has a frontage of 60 feet thereon, extending back between parallel lines to a depth of 136 feet, be the same more or less but subject to all legal highways.

GREAT LAKES CITY:

Great Lakes City is the western metropolis of Ohio, a railroad center and the trading point for a vast, productive, and wealthy agricultural community. It is a merchandising mart and an industrial, manufacturing, and distributing center for a population of one million people. Its schools, churches, chamber of commerce, and public agencies are characteristic of its youth, its civic vision, and its social and economic stability. During the late depression it suffered less than most metropolitan areas, and its recovery has been rapid. It has a good local government and high civic ideals, and is altogether a prosperous and forward-looking community. Its industries, railroads, and merchandising and financial agencies indicate a continuance of more than a normal increase in population and wealth.

THE NEIGHBORHOOD:

South Jones Street is located four and one-half miles northwest of the center of the city. It is reached by surface street cars at its intersection with West Market Street, two blocks from the subject property, and the running time to the central business district is twenty minutes. Intersecting surface lines at transfer points bring all parts of the city into easy communication. City-owned and city-operated bus lines, connecting with car lines and reaching newly developed areas, furnish additional transportation for this neighborhood.

This area was developed twenty-two years ago. It has all public utilities, paved streets, and easy access to boulevards that reach the business districts with a minimum of traffic hazards. The entire area is substantially level.

ZONING AND RESTRICTIONS:

The neighborhood is restricted to residential use with the exception of the four corners at the intersection of Jones and Market Streets, where retail business and automobile service stations are located. These restrictions, in conformity with later zoning, have produced single, two-family, and apartment houses. South Jones Street in this neighborhood has nine single houses, eighteen two-family houses, eleven apartment buildings, and four vacant lots. It is typical of the several streets north and south of Market Street which comprise the neighborhood.

This is not a new neighborhood, and it is not a stylish one. As a whole, the section has suffered from age and undesirable racial encroachment. It is a secondary apartment neighborhood in which buildings have an average age of eighteen years. It is attractive to middle-class families, whose incomes range from $1,500 to $3,000 per year and whose rental outlay lies between $30 and $60 per month. Sixty percent of single and two-family houses are owner-occupied. Statistics show an over-all residential vacancy ratio of 8 percent for 1935, 6.5 percent for 1936, and 5 percent as of September 1, 1937. In 1935 and 1936, a total of seventy-one families moved into it. This movement in a population of approximately 900 families indicates a stable and desirable rental situation for the neighborhood.

LAND:

The values of this land, established by comparison with sales, offers to purchase, and brokers' listings, is estimated to be $4,000. It now serves its highest and best use.

BUILDING:

The building was erected in 1924 and contains ten rentable suites—eight with five rooms and one bath each, and two with three rooms and one bath each. It is a two-story and English basement building, with wire-cut tapestry brick with stone trim on all elevations. The two rentable suites of three rooms and bath are located in the basement, and there are four of the five-room suites on each of the first and second floors; in addition, there is a three-room basement suite for the janitor.

CONSTRUCTION:

The basement has concrete floors and a ceiling height of nine feet. The three suites located in the front of the basement are separated by a twelve-inch brick fire wall from the rear basement, which contains the boiler room, the laundry, and the lockers. The ceiling of the rear basement is plastered, and the walls are painted hollow tile. An examination of the plans in the building commissioner's office showed footings three feet below floor level and three-inch by twelve-inch yellow pine floor joists on twelve-inch centers, braced and bridged in conformity with good building practice. There is no evidence of termites or dry rot. Basement walls are eighteen inches thick, while the walls above grade are thirteen inches thick and have a four-inch brick course over eight-inch hollow tile.

The roof is of six-ply composition built-up construction and slopes to roof drains at the rear of the building.

All outside openings are fully weather-stripped. There is one principal entrance to the building from South Jones Street. The fire escape and service stairways are at the rear. The lobby has plastered and painted walls with tile floor and oak stairways leading to the basement and upper floors. Center halls, extending lengthwise on the first and second floors, divide the space so that there are two suites on each side of each hall.

INTERIOR OF SUITES:

All floors are seven-eighths-inch oak over diagonally laid subfloors. The doors and trim are birch, and the kitchen floors are covered with linoleum. The bathrooms have tile floors, built-in tubs with overhead showers, three-quarters tiled walls, and a fair grade of fixtures, with pedestal washstands and semi-noiseless, low flush toilets.

Each five-room suite has two bedrooms, each with a clothes closet; living room with guest closet, bookshelves, gas log fireplace, and birch mantle; dining room with corner china cabinets; and kitchen equipped with cupboards, shelves, roll-rim sink, broom closet, ironing board, and refrigerator space. The light is fair in all rooms, but it does not meet modern requirements in better-planned buildings. The three-room suites have the same type of floors and trim as the larger suites. They have one bedroom each and an in-a-door bed in the living room. Bathroom fixtures are identical with those of the larger suites.

Each kitchen of the ten rentable suites is equipped with a gas stove and an electric refrigerator. All window shades, curtain rods, and gas logs also belong to the property.

EQUIPMENT:

A sixty-horsepower steam boiler from the Titusville Iron works (Titusville, Pa.) was installed when the building was erected and has been efficiently maintained. Its record of performance is good. There is a submerged hot-water heating installation with a 300-gallon tank and an instantaneous gas-heated hot-water unit for use in summer months. The heating system is a two-pipe return system with low-type radiators. All

heating pipes are covered. Radiation seems adequate, and the tenants appear satisfied.

Cast-iron water piping has been used in all cases except for elbows, fittings, and valves of the hot-water lines which are of copper. There is no evidence of serious rust or corrosion. All electric wires are in conduits; outlets are sufficient in number. However, electric fixtures are out of date and should be replaced. All gutters and downspouts are copper. Call tubes and mailboxes for all suites are located in the vestibule.

CONDITION:

The general condition of the building is good, with the following exceptions: All exterior woodwork and the iron stairways in the rear should be painted. Old electric fixtures in the living rooms, dining rooms, and the entrance vestibule should be replaced. The same applies to the hall carpeting on the first and second floors. These improvements will cost approximately $600 and are considered necessary for continued desirability of the suites.

TAX VALUATION:

This property is valued for taxation as follows:

Land	$ 3,600.00
Building	12,600.00
Total	$16,200.00

The tax rate is $25.60 per $1,000 valuation, making the present annual taxes $414.72.

REPRODUCTION COST (NEW):

Building 42′ · 90′ · 30′ = 113,400 cu. ft.		
113,400 cu. ft. @ $0.35 = estimated cost new		$39,600.00
Depreciation		
Physical	$ 6,500.00	
Equipment (restoration)	600.00	
Obsolescence (changing neighborhood) *	10,000.00	17,100.00
Indicated value of building		22,500.00
Value of land (comparison)		4,000.00
Indicated property value		$26,500.00

* In a consideration of the loss through the changing neighborhood, it was estimated that this building after expenditure of $600 for renewal of equipment, if located in a 100 percent neighborhood, would bring rentals above present levels of $10 per month for the five-room suites and $5.00 per month for the three-room suites. If this added annual rental of $1,080, less 10 percent for vacancies and 5 percent for management charge, is treated as added income for the remaining life of the building and the present worth of such estimated additional income is computed, we have 10.594 (Inwood factor for 20 years at 7%) · $918, or $9,725. This is considered for purposes of this appraisal to be $10,000.

ECONOMIC PROCEDURE:

Gross Income

4 suites @ \$50 per month = \$200		\$2,400.00
4 suites @ \$45 per month = 180		2,160.00
2 suites @ \$35 per month = 70		840.00
Total gross income		\$5,400.00
Less: Vacancy and rental loss (10%)		540.00
Gross effective rental		\$4,860.00
Operating Costs		
	Per Year	
Coal (98 tons @ \$5)	\$490.00	
Decorating, paint, and shades	400.00	
Exterior maintenance	100.00	
Water (actual)	110.00	
Electricity (actual)	220.00	
Gas (actual)	50.00	
Janitor (plus suite)	240.00	
Miscellaneous	70.00	
Management	245.00	
		1,925.00
Fixed Charges		
Taxes (actual)	414.72	
Insurance (actual)	172.00	
		586.72
Reserve for Replacements		
Refrigerators (15-year life)	84.00	
Stoves (15-year life)	20.00	
Carpet (8-year life)	27.00	
Roof (15-year life)	24.00	
Boiler (15-year life)	50.00	205.00
Total charges		\$2,716.72
Net income to property		2,143.28
Say		\$2,150.00

ASSUMPTIONS:

1. That rental levels may be stabilized upon the preceding basis for twenty years.
2. That the property residual pattern best fits this property.
3. That a 7 percent interest rate for the investor and a 4 percent basis for land reversion are fair and equitable.
4. That the Inwood procedure of the compound interest valuation premise is indicated.

PROCEDURE:

10.594 Inwood factor 20 year	
7% · $2,150	$22,777.10
0.4564 Factor for 20 year reversion	
4% · $4,000	1,825.60
Indicated value of property	$24,602.70
Say	$24,600.00

Comparative Results:

Reproduction cost, less depreciation	$26,500.00
Capitalization of estimated net income	24,600.00
Estimate of market value	24,500.00

CERTIFICATION:

I hereby certify that I have examined this property personally; that I have checked and considered rentals paid in a wide neighborhood; that I have compared this building and these rental units with other similar property; and that I have considered maintenance, management, and competitive prices. As a result of the foregoing and other things, I have placed my reliance in the economic approach, using physical reproduction only as a check thereon. In my opinion the property herein appraised has a market value as of this date, December 11, 1937, of *twenty-four thousand, five hundred dollars* ($24,500).

Richard Roe, M.A.I.
Appraiser

c. *Investing in a Mine*

In the case of an ore body, the mining engineer can estimate with a high degree of probability the quantity of ore underlying the property and also determine the investment in plant to mine and smelt the ore. Assume that a given ore deposit is found to be 600,000 tons and that an economical plant can be installed to mine and smelt the ore at the rate of 60,000 tons per year. Assume also that it is estimated that the net annual income from operations will be $200,000. This income is based on a cost which includes a full write-off or depreciation of the plant investment in 10 years. What price should one pay for this property to meet the following investment requirements:

1. That the original price paid be returned in 10 years with interest at 10 percent compounded annually; and
2. That the annual net income from operations be invested in securities bearing 3 percent interest.

In the matter of requirement (2), we find

$$A_F = \$200{,}000 \cdot \left(\frac{1}{\text{sinking-fund factor}}\right)$$
$$= \frac{\$200{,}000}{0.08723}$$
$$= \$2{,}300{,}000 \text{ (approximately)}$$

The present worth of this expectancy on the basis of 10 percent interest is,

$$P = \$2{,}300{,}000 \text{ (present worth factor for 10 years at 10 percent)}$$
$$= \$2{,}300{,}000 \,(0.3855)$$
$$= \$886{,}650 \text{ (approximately)}$$

This, then, is the price to be paid for the property plus the mining and smelting plant to meet the investment demands above specified.

TABLE XXXVII

VALUES OF THE COMPOUNDED AMOUNT FACTOR $(1+R)^N$

N	3%	4%	5%	6%	7%	8%	10%
1	1.030	1.040	1.050	1.060	1.070	1.080	1.100
2	1.061	1.082	1.103	1.124	1.145	1.166	1.210
3	1.093	1.125	1.158	1.191	1.225	1.260	1.331
4	1.126	1.170	1.216	1.262	1.311	1.360	1.464
5	1.159	1.217	1.276	1.338	1.403	1.469	1.611
6	1.194	1.265	1.340	1.419	1.501	1.587	1.772
7	1.230	1.316	1.407	1.504	1.606	1.714	1.949
8	1.267	1.369	1.477	1.594	1.718	1.851	2.144
9	1.305	1.423	1.551	1.689	1.838	1.999	2.358
10	1.344	1.480	1.629	1.791	1.967	2.159	2.594
11	1.384	1.539	1.710	1.898	2.105	2.332	2.853
12	1.426	1.601	1.796	2.012	2.252	2.518	3.138
13	1.469	1.665	1.886	2.133	2.410	2.720	3.452
14	1.513	1.732	1.980	2.261	2.579	2.937	3.797
15	1.558	1.801	2.079	2.397	2.759	3.172	4.177
16	1.605	1.873	2.183	2.540	2.952	3.426	4.595
17	1.653	1.948	2.292	2.693	3.159	3.700	5.054
18	1.702	2.026	2.407	2.854	3.380	3.996	5.560
19	1.754	2.107	2.527	3.026	3.617	4.316	6.116
20	1.806	2.191	2.653	3.207	3.870	4.661	6.727
21	1.860	2.279	2.786	3.400	4.141	5.034	7.400
22	1.916	2.370	2.925	3.604	4.430	5.437	8.140
23	1.974	2.465	3.072	3.820	4.741	5.871	8.954
24	2.033	2.563	3.225	4.049	5.072	6.341	9.850
25	2.094	2.666	3.386	4.292	5.427	6.848	10.835

TABLE XXXVIII

VALUES OF PRESENT WORTH FACTOR

$$\frac{1}{(1+R)^N}$$

N	3%	4%	5%	6%	7%	8%
1	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259
2	0.9426	0.9246	0.9070	0.8900	0.8734	0.8574
3	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938
4	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350
5	0.8625	0.8219	0.7835	0.7473	0.7130	0.6806
6	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302
7	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835
8	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403
9	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002
10	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632
11	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289
12	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971
13	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677
14	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405
15	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152
16	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919
17	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703
18	0.5874	0.4936	0.4155	0.3503	0.2959	0.2502
19	0.5703	0.4746	0.3957	0.3305	0.2765	0.2317
20	0.5537	0.4564	0.3769	0.3118	0.2584	0.2145
21	0.5375	0.4388	0.3589	0.2942	0.2415	0.1987
22	0.5219	0.4220	0.3418	0.2775	0.2257	0.1839
23	0.5067	0.4057	0.3256	0.2618	0.2109	0.1703
24	0.4919	0.3901	0.3101	0.2470	0.1971	0.1577
25	0.4776	0.3751	0.2953	0.2330	0.1842	0.1460

TABLE XXXIX

VALUES OF SINKING FUND FACTORS

$$\frac{R}{(1+R)^N-1}$$

N	3%	4%	5%	6%	7%
1	1.00000	1.00000	1.00000	1.00000	1.00000
2	0.49261	0.49020	0.48780	0.48544	0.48309
3	0.32353	0.32035	0.31721	0.31411	0.31106
4	0.23903	0.23549	0.23201	0.22859	0.22523
5	0.18835	0.18463	0.18097	0.17740	0.17389
6	0.15460	0.15076	0.14702	0.14336	0.13980
7	0.13051	0.12661	0.12282	0.11914	0.11555
8	0.11246	0.10853	0.10472	0.10104	0.09747
9	0.99843	0.09449	0.01069	0.08702	0.08349
10	0.08723	0.08329	0.07950	0.07587	0.07238
11	0.07808	0.07415	0.07039	0.06679	0.06336
12	0.07046	0.06655	0.06283	0.05928	0.05590
13	0.06403	0.06014	0.05646	0.05296	0.04965
14	0.05853	0.05467	0.05102	0.04758	0.04434
15	0.05377	0.04944	0.04634	0.04296	0.03979
16	0.04961	0.04582	0.04227	0.03895	0.03586
17	0.04595	0.04220	0.03870	0.03544	0.03243
18	0.04271	0.03899	0.35555	0.03236	0.02941
19	0.03981	0.03614	0.03275	0.02962	0.02675
20	0.03722	0.03358	0.03024	0.02718	0.02439
21	0.03487	0.03128	0.02800	0.02500	0.02229
22	0.03275	0.02920	0.02597	0.02305	0.02041
23	0.03081	0.02731	0.02414	0.02128	0.01871
24	0.02905	0.02559	0.02247	0.01968	0.01719
25	0.02743	0.02401	0.02095	0.01581	0.01823

IX

DEPRECIATION

WHEN AN ASSET such as a machine, a truck, a building, or furniture is purchased by a corporation, the value of the asset is recorded in the books of account as the purchase price. If, for example, a new milling machine is bought for $2,000, this amount is entered in the asset accounts to balance the transfer of $2,000 from cash or to balance an increase of $2,000 in accounts payable, if the machine is purchased on credit. In this manner, the books show what disposition is made of funds or what is received for liabilities incurred. If an exact duplicate of this same machine is subsequently purchased at a bankruptcy sale for $1,000, the "value" entered in the books of account, in this instance, is $1,000.

The economic worth, that is, the value to the business is the same in the case of each machine but the book value is not the same. Book value is an accounting term, designed for auditing purposes in accounting for the expenditures of funds.

After a period of use, an asset such as a machine or a building be-

comes worn. After some years, it becomes worn out and needs to be replaced. This wearing-out process is termed physical depreciation. If the asset is kept in good repair and is properly taken care of, it will last longer. The number of years required for an asset to become useless, that is, physically unusable, is difficult to determine. Assets are often replaced with new and improved equipment *before* such assets become physically unusuable. Such replacements are prompted by the need for lowering costs to meet a competitive market. Thus, assets still physically usable may become economically unusable, and may be said to have suffered economic depreciation. Circumstances contributing to economic depreciation will be described subsequently. At this time we will inquire into the procedures by which depreciation is given effect in the books of account. The opening entry in the asset account when a machine is purchased is the purchase price.* This is the opening book value. What should the book value be after, say, three years and how may it be determined? The book value of the machinery and equipment of a new plant after three years of operation may be stated as

Machinery and Equipment	$250,000	
Less Reserve for Depreciation	50,000	
Net value		$200,000

The depreciation reserve may be estimated on the basis of the anticipated years of usefulness of each item or group of similar items in the account by use of one of the following procedures.

1. THE STRAIGHT-LINE METHOD

The straight-line method is based on the proposition that, if a machine or structure has an estimated life of N years, its value should be written down $\frac{1}{N}$ each year. Accordingly, successive values at the end of each year of use, when plotted against years of life, would fall on a straight line, beginning at first cost and terminating at zero. Thus a machine purchased for $10,000 and having an expected life of 10 years would depreciate $1,000 each year. Accordingly, after 4 years of use, it would have an estimated book value of $6,000.

This method of accounting for depreciation is most frequently in use and is a method allowed by the public utility commissions and

* This may, at times, include transportation and placement costs, that is, it may represent the cost of equipment installed and ready to operate.

the courts in determining the costs of power furnished by public utility companies. Some authorities state that, after a machine or structure has completed its estimated life, it still has a scrap value and this should be included in estimating the annual depreciation. If, for example, a machine costing $5,000 has an estimated life of 10 years, and if it is also estimated that it will have a scrap value of $500, then the annual depreciation by the straight-line method should then be 1/10 of ($5,000 — $500) or $450. We are inclined to believe that such refinements are not in harmony with the degree of accuracy with which the useful life of the machine may be predicted in the first place.*

2. PRESENT DEPRECIATED WORTH

If a property is to be sold or mortgaged to secure a bond issue, or its present value needs to be determined for other reasons, an appraisal of its value is made. Such an appraisal value will differ from the book value because it is based on current prices as well as on years of use, and state of repair. The procedure in applying depreciation calculations by the straight-line method in such cases is as follows.

A truck, for example, is found to have been purchased five years ago at the price of $3,000. Today it would cost, say, $2,500. Accordingly, if its estimated useful life is ten years, and though its book value may be recorded as $3,000 — $1,500 = $1,500, its *present* depreciated worth would be determined as $2,500 — $1,250 = $1,250. Thus, this procedure of value determination consists of assuming the purchase price to have been $2,500, the present price; accepting the 10-year life estimate; and writing off for each year of its use one tenth of the present price ($250). Appraisals of this character also take account of the condition or state of repair of the machine being valued. How this "taking account" of the condition of the machine proceeds will not be considered at this time.

3. THE SINKING-FUND METHOD

The sinking-fund method of accounting for depreciation is based on the assumption that each year a fixed sum is to be set aside from surplus and put at compound interest and the total amount of such equal annual sums together with the accumulated interest will equal the first cost, or first cost less estimated salvage value, of the equip-

* Scrap value may even be negative.

ment at the end of its expected life. Let such an annuity or annual amount set up in the depreciation reserve and put at interest be designated D. Then, if the annual interest is R, the depreciation reserve at the end of each year will appear as follows:

At the end of	Depreciation Reserve
1st year	D
2nd year	$D(1+R)+D$
3rd year	$D(1+R)^2+D(1+R)+D$
4th year	$D(1+R)^3+D(1+R)^2+D(1+R)+D$
5th year	$D(1+R)^4+D(1+R)^3+D(1+R)^2+D(1+R)+D$
Nth year	$D(1+R)^{N-1}+D(1+R)^{N-2}\ldots D(1+R)+D$
	$=D[(1+R)^{N-1}+(1+R)^{N-2}\ldots(1+R)+1]$
	$=D\dfrac{(1+R)^N-1}{R}$

The amount of the depreciation reserve at the end of the Nth year, which is at the end of the expected life of the equipment, must equal the original investment or first cost of the equipment which is P. Therefore

$$P=\frac{D}{R}[(1+R)^N-1]$$

whereupon

$$D=P\left[\frac{R}{(1+R)^N-1}\right]$$

$$=P\cdot[\text{sinking-fund factor}]$$

If D is expressed as a percentage of first cost, then the

$$\text{Annual rate of depreciation } \frac{D}{P}=\frac{R}{(1+R)^N-1}$$

Example: A machine has an estimated life of 10 years. What is the depreciation rate when interest is taken at 6 percent?

Answer:

$$\text{Rate of depreciation } \frac{0.06}{(1+0.06)^{10}-1}$$

$$7.6 \text{ percent}$$

Note 1: If the first cost of the machine is $5,000, what amount is to be set up annually from surplus in the depreciation reserve?

Note 2: If the straight-line method of depreciation had been used, the annual reserve set up would be 10 percent of the first cost, or $500. The difference be-

tween the two methods resides in the assumption that, in the compound interest case, the reserve fund is put at interest, whereas in the straight-line case the assumption is that the reserve fund is idle. As a matter of fact, neither assumption is true. What actually occurs in a majority of cases is that the setting up of a reserve is merely a bookkeeping entry and the reserve fund is not distinguished from any other funds used in the business and therefore earns whatever percentage the other funds of the business earn.

The sinking-fund method of accounting for depreciation is not used in the manufacturing industries nor in the public utilities except, perhaps, in some unusual cases, examples of which are very rare. It has little practical value.

4. THE DIMINISHING-BALANCE METHOD

The diminishing-balance method is based on the supposition that machines and structures wear out faster toward the latter years of their useful life than in their earlier years and hence repairs and maintenance costs in the earlier years are comparatively light. Accordingly, it seems equitable, according to this theory, to charge or write off greater depreciation in the earlier years and less in the late years in order that the sum of depreciation and maintenance and repairs shall be uniform throughout the useful life of the equipment. A method of accomplishing this result is to charge off a constant percentage each year on the *book value* or remaining value. Thus, if a machine is valued at $10,000 when acquired, and is estimated to have a scrap value of $2,000 at the end of 10 years, the depreciation written off at the end of the first year will be some percentage which will determine the write-off to be established each year such that by its application to successive book value it will reduce $10,000 to $2,000 in 10 years and is found from the following formula:

Let $X =$ the constant percentage to be written off each year
$P =$ the initial book value of the investment
$S =$ the estimated scrap value at the end of N years
$N =$ the years of useful life of the equipment.

It can be demonstrated that

$$X = 1 - \sqrt[N]{\frac{S}{P}}$$

The depreciated book value by this method will be, for the

1st year, $P\,(1 - X)$
2nd year, $P\,(1 - X) - P\,(1 - X)\,X = P\,(1 - X)^2$
Nth year, $P\,(1 - X)^N$

This formula is meaningless if $S = O$, hence, some scrap value must be assumed. This method is sometimes known as the Matheson method. Its use is limited to some features of public utility accounting.

5. THE BOOK VALUE OF A DEPRECIATED ASSET

The book value of a depreciated asset is the original investment minus the depreciation reserve. Since the amount of the depreciation reserve may be determined by different methods of accounting for depreciation, it is obvious that the book value of an asset at any time depends on the method used for estimating the depreciation or establishing the depreciation reserve.

a. The book value of an asset according to straight-line depreciation is

$$\text{Book value} = P - DN$$

For example, if the initial book value (P) of the asset is \$10,000 and it is estimated to have a life of 10 years, then

$$D = \$1{,}000$$

The book value at the end of 4 years will be

$$\begin{aligned}\text{Book value} &= \$10{,}000 - (\$1{,}000 \cdot 4)\\ &= \$6{,}000\end{aligned}$$

b. The book value of an asset according to the sinking-fund method of accounting for depreciation is

$$\text{Book value} = P - D\left[\frac{(1+R)^U - 1}{R}\right]$$

where U is the number of years the asset has been used. But D in turn depends on the estimated years (N) of life of the asset, and as has been shown is

$$D = P\left[\frac{R}{(1+R)^N - 1}\right]$$

Hence

$$\begin{aligned}\text{Book value} &= P - P\left[\frac{R}{(1+R)^N - 1}\right] \cdot \left[\frac{(1+R)^U - 1}{R}\right]\\ &= P\left[1 - \frac{(1+R)^U - 1}{(1+R)^N - 1}\right]\end{aligned}$$

The quantity in parentheses may be written

$$\frac{1-\dfrac{1}{(1+R)^{N-U}}}{1-\dfrac{1}{(1+R)^{N}}}$$

or

$$\frac{T_{N-U}}{T_N}$$

in which T is known as the *term factor*. Hence

$$\text{Book value} = P \cdot \frac{T_{N-U}}{T_N}$$

This is known as the Benitz Transformation.*

Values of T are given in Table XLIV, page 308. In using this table it is to be noted that T_{N-U} is the term factor for the number of years of remaining life of the equipment. Thus, if N = 10 and U = 4, then the term factor is T_6. If the interest rate is 6 percent, then the value of T_6 for 6 percent is 0.29511.

For example, if the initial book value of an asset is \$10,000 and it has been in use 4 years and the interest rate is taken at 6 percent, then the

$$\text{Book value} = \$10{,}000 \left(\frac{0.29511}{0.44161}\right) = \$6.675$$

c. The book value of an asset after a given number of years of use, according to the diminishing-balance method is

$$\text{Book value} = P\,(1 - X)^U$$

where U = the number of years the equipment has been in use.

$$X = 1 - \sqrt[N]{\frac{S}{P}}$$

$$\text{Book value} = P\left[1 - \left(1 - \sqrt[N]{\frac{S}{P}}\right)\right]^U$$

$$= P\left(\sqrt[N]{\frac{S}{P}}\right)^U$$

* See Goldman, *Financial Engineering*, Second Edition, page 44. John Wiley and Sons, Inc., New York, 1923.

Thus, if the initial book value of the equipment is \$10,000, it has a life expectancy of 10 years, and its scrap value at the end of N years is estimated to be \$2,000, then the book value at the end of 4 years of use is

$$\text{Book value} = \$10{,}000 \left(\sqrt[10]{\frac{2{,}000}{10{,}000}} \right)^4$$
$$= \$5{,}253$$

6. DEPRECIATION AS AN ELEMENT OF COST

On the theory that the depreciation write-off each year is a charge in the costs of production, through which the asset is being gradually sold to the purchasers of the company's products over the years during which the equipment is used, the question arises: What is the amount of depreciation to be charged into the cost of production each year by each of the above methods? Obviously, by straight-line depreciation it is the annual addition to the depreciation reserve. For example, if the initial book value of an investment is \$10,000 and its useful life is estimated to be 10 years, then the depreciation reserve will be increased each year by \$1,000, and the \$1,000 will also be absorbed in the cost of production. By the sinking-fund method, the annual deposit in the sinking fund at 6 percent interest is

$$D = \$10{,}000\ (0.07587) = \$758.7$$

But is this the amount which enters into the cost of production each year? It is not. The amount D as given above is supposed to be put into a fund and is estimated to draw 6 percent interest. But no such fund exists as a rule. What happens is that the sinking-fund deposits *plus 6 percent interest on the fund* is the *amount set up* in the reserve, and the addition to the reserve each year is D plus the annual interest of the amount in the reserve during the year. It is this *addition* to the reserve each year which is the amount of depreciation charged to the cost of production during the year. By this process, therefore, the amount put in the fund (D) plus the interest on the sinking fund is obtained from the customers who buy the products of the company. For example, during the fourth year, in the above case, the amount of depreciation which is charged as a cost of production is \$758.70 + \$144.90 = \$903.60, in which \$144.90 is the interest on the amount in the sinking fund. In the tenth year, the

depreciation which is charged as a cost of production is $758.70 + $523.10 = $1,281.80. Accordingly, the amounts of annual depreciation as determined above are the amounts charged each year in the cost of production and are equal to the amounts set up each year in the depreciation reserve. The sum of the amounts so determined for 10 years is equal to the initial book value of the investment. It is important to remember that the annual sinking-fund deposit (D) is *not* the annual depreciation charge in the cost of production.

The same method for determining the depreciation to be charged to the cost of production is used in the other examples of depreciation accounting referred to above.

Problem. Determine the amount of depreciation charged to the cost of production in the example given above for the fourth year when the diminishing-balance method of accounting for depreciation is used.

7. SOME GENERAL CONSIDERATIONS

The straight-line method of depreciation is generally preferred for several reasons. In the first place, since it is primarily a means for accounting for the service cost or the cost of using a capital asset, and the estimated life at best is a rough approximation, any refinements in calculation are not appropriate. In the next place, granting that the purpose of the depreciation reserve is to provide a fund for the replacement of the equipment at the end of its natural life, the change in the purchasing power of money may cause the fund to be insufficient.* Again, interest rates may change during the period of accumulation of the reserve. It is also to be borne in mind that depreciation reserve is generally not in cash put at interest, as the sinking-fund calculation, for example, assumed, but is usually a book entry indicating a withdrawal from surplus and as such establishes a safeguard against false profits and the payment of dividends from false surplus.

The above reasons, aside from the question of simplicity, tend to cause the straight-line method to be more generally accepted. The question may now be raised: What practical differences, if any, result from the use of a high or low rate of depreciation?

A very conservative management tends to use high rates of depreciation resulting in an early write-down of capital assets merely for the sake of safety. On the other hand, high depreciation means high

* See Chapter XIV, page 336.

cost estimates which may be misleading, particularly if by such means a manufacturer may be led to believe that certain contracts offered cannot be taken at a profit, whereas the use of a more reasonable depreciation allowance would indicate that the business could be undertaken at a fair profit. High depreciations are generally favored, however, because of the consequent lowering of Federal income taxes. The Federal Government, however, will not allow the charging, to operating costs, of depreciation which appears to be excessive. Again it must be realized that the ownership of property often resides in two classes of security interests—the stockholders and the bondholders. The stockholders are interested in obtaining maximum dividend returns and therefore favor a low depreciation charge. The bondholders, on the other hand, are not interested in dividends but are interested in maintaining the value of the fixed assets which are pledged through mortgage as security for the bonds.

A high rate of depreciation favors the bondholder because it tends to maintain the value of the fixed assets. But insufficient depreciation reserve may give a false ratio between the value of the fixed assets and the underlying bonds, and may therefore mislead the purchaser as to the security of his investment. For this reason, the public utility commissions authorizing the issuance of bonds by public service corporations make diligent inquiry into the value of the physical assets, an important factor of such inquiry being the depreciation reserves maintained or the rates of depreciation allowed. The commissions and the courts, in case the rulings of the commission are appealed, also give serious consideration to the problem of depreciation in the matter of rates or charges for service allowed.

8. CAUSES OF DEPRECIATION

a. *Normal Use.* There are two principal causes for depreciation of a capital asset or physical property. These are physical and economic. Physical depreciation is evidenced by what is termed the state of repair. If a machine, for example, is kept clean from dust, dirt and grit, its bearings are always well oiled, its worn parts are adjusted or replaced from time to time, it will have a much longer life of physical usefulness than if the above particulars are not attended to. Sometimes machines or pieces of equipment, such as tanks, piping, and valves used in the chemical industries, become eroded in ways which do not permit of repairs. The physical life of such equipment is relatively short and therefore its rate of physical depreciation is relatively

high. The decline in physical usefulness under the conditions noted above is frequently referred to as depreciation through normal use, which means the conditions of use which may be anticipated to obtain in the average plant.

b. *Deferred Maintenance.* When property has not been given even ordinary and reasonable care, and when normal repairs and replacements of parts have not been made, an estimate of its value usually provides for neglect of this nature under the heading of "deferred maintenance." This account calls attention to the expenditures which should be made to bring the property up to its normal depreciation value; it is frequently used in railroad accounting. It has been found by experience that a certain sum of money should be spent annually per mile of right-of-way to keep the roadbed in good condition. If the records show that less than this sum was spent in upkeep and maintenance, then the difference between what was actually spent and what should have been spent may be deducted from the surplus as a reserve against deferred maintenance.

c. *Accidental.* Physical damage due to fires or other calamities such as wind storms result in deterioration in value of buildings and machinery which is not predictable but nevertheless must be accounted for. Such accounting is made by appraisal for which no formulated procedure exists. The loss through such damages, if the property is covered by insurance, may be recovered fully or in part, depending on the specifications of the insurance policy.

Causes of *economic* depreciation are the following.

d. *Supersession.* When, through an advance in the arts, a new machine is developed and put on the market, and it operates much more efficiently than other machines used for the same purpose, these other machines used for the same purpose are said to be *superseded.* For example, when steam turbines became generally used, particularly in combination with driving electrical generators, the reciprocating, slow-speed steam engines then in common use became superseded because they were not so economical as steam turbines. Again if a manufacturer is using a machine which produces 100 units per hour and an improved machine can be purchased which will produce 1,000 units per hour, and its initial cost is not much greater than that of the machine now being used, it is obvious that the manufacturer cannot afford to be without the new machine. The one he is using may be in perfect shape mechanically, but from the point of view of its economic usefulness it is said to be superseded. Supersession has nothing to do

with the state of mechanical perfection; it is based entirely on comparative economic usefulness. There is no basis for estimating the probability of specific declines in value because of supersession. It may be roughly accounted for at a time of revaluation in case of the sale of property or at the time of merger.

e. *Obsolescence.* Obsolete machinery and equipment is that which can no longer serve a useful purpose. For example, when the fifty-ninth power station of the Interborough Rapid Transit Company in New York City was built, it was equipped with large reciprocating engines. The builder of the engines invested in patterns, jigs, and fixtures, in anticipation of orders for similar engines from other power companies and did not charge their total cost to the building of the Interborough's engines. The steam turbine came into commercial use quite rapidly at this period and no more engines of this type were desired by the power companies. Accordingly, all the expensive equipment of the engine builder for building these engines became obsolete since it could no longer be used for the purpose for which intended. *Obsolescence* arises from the advance of the arts and cannot be predicted. A prudent management, however, operating in an art which is very active would set aside reserves from surplus in anticipation of this contingency. The term *obsolete* is frequently used to describe machinery which has declined in value through supersession, obsolescence, and inadequacy.

f. *Inadequacy.* When a machine, for example, is not of sufficient capacity to accommodate the demands of a growing business and needs to be replaced by a larger machine because a duplicate or an additional similar machine will not suffice, it must be retired although it may still be in good physical condition and may also be economically usable under other circumstances. The retired machine may be sold to others who can use it, but at a reduced price as a second-hand machine. Suppose a motor is no longer adequate and its depreciated value is, say, $1,000. If it is sold as a second-hand machine at $200, then there is an $800 loss. That is, $800 of its purchase price has not been recovered in costs; it must be written off. The amount that is written off is the amount of depreciation because of inadequacy. This type of depreciation cannot be predicted at the time of purchase and hence can only be handled as it occurs.

g. *An Example.* The principal cause of depreciation of different types of equipment of a telephone company are the ones given in Table XL.

TABLE XL

DEPRECIATION (TELEPHONE COMPANY)

Causes of Depreciation	Kind of Depreciation (Predictable Effect)	Plant Characteristics Affected	Illustrative Cases
Action of elements	Rot, rust, and decay	Physical condition	Deterioration of wire
Organic agencies	Rot, rust, and decay	Physical condition	Rotting of poles
Use in operation	Wear and tear	Physical condition	Deterioration of autos in use
Injury	Wear and tear	Physical condition	Underground cable injured by pick
Storms and casualties	Wear and tear	Physical condition	Poles destroyed by sleet storm
Improvements in the art	Obsolescence	Function	Substitution of call indicator positions for Manual "B" positions in central offices
Growth of communities served	Inadequacy	Capacity	Substitution of a larger unit, such as switchboard or cable
More intensive service	Inadequacy	Capacity	Substitution of a larger unit, such as switchboard or cable
Fires	Damage	Physical condition	Burning of station apparatus in building fire
Advancing social standards	Public requirements	Character and location	Lines retired due to putting wires of thoroughfares underground
Public convenience	Public requirements	Character and location	Poles retired because of highway changes

9. SOME POINTS OF VIEW CONCERNING DEPRECIATION

Depreciation of machinery and equipment is an item of operating cost. Although a machine tool may take 10 or 15 years to become used up or worn out, nevertheless it must be charged for each month in factory cost, so that the products manufactured during the month may be correctly costed. To accomplish this accounting, it is necessary to estimate the probable life of the machine. Many years' experience with certain standard types of buildings and machines has provided

engineers with some basis for estimating their probable lives, although these estimates differ somewhat among the various authorities.

There are several points of view or theories on which the accountings for depreciation are based. One idea underlying the accounting procedure is to provide for the recovery of capital investments used in the business. It is argued that a machine costing $10,000 and having a life expectancy of 10 years will in effect be sold piecemeal to the consuming public at the rate of $1,000 per year. Accordingly, $1,000 of the total annual income from sales is income derived from selling one tenth of the value of the machine. In 10 years' time the entire machine is sold and the capital invested is recovered. During 10 years' time, however, the changes in the prices of materials and labor are usually so great (either up or down) that one may have to pay either $12,000 for a new duplicate machine or it may be procured for $7,500. Again technological advances may be so great that an entirely new type of machine, capable of doing much more work of better quality, may be procured for half the price paid for the old machine. Hence, during the life of the machine its current replacement value may either rise or fall. If it rises, the question is: Shall the owner increase the depreciation charges he is accruing in his costs of production so that he sells the machine to his customers at the *current market prices*, or should he give his customers the advantage of the lower prices prevailing in the earlier market at the time he purchased the machine? It is obvious that the same logic compels one to ask: Should he lower his depreciation charge if the current replacement price is lower? If he fails to raise the depreciation charge as the replacement cost rises, while he may provide for the recovery of his capital investment he is not charging his customers "current value" for the use of the machine in the *current* market. If such a rise in replacement cost prevails through the major part of the useful life of the machine, it is obvious that the owner will not have recovered on the basis of the old depreciation charges a sufficient sum of money to replace the equipment used up in the customer's service.

But it has been expressed in many court decisions that the investor is entitled only to the recovery of the original capital invested. Accordingly, if the depreciation reserve based on the original investment is not sufficient for replacement purpose, any additional funds required for such replacement must be provided from surplus or from borrowed capital if the company has not sufficient funds.*

* Variations of the yardstick-dollar complicates the problem (see Chapter XIV, page 336.

The United States Treasury Department Bureau of Internal Revenue in its "Bulletin F (revised January 1942)" * instructs taxpayers on the Government's policies with respect of depreciation as follows.

DEPRECIATION AND OBSOLESCENCE – DEFINITIONS

The Federal income tax in general is based upon net income of a specified period designated as the taxable year. The production of net income usually involves the use of capital assets which wear out, become exhausted, or are consumed in such use. The wearing out, exhaustion, or consumption usually is gradual, extending over a period of years. It is ordinarily called depreciation, and the period over which it extends is the normal useful life of the asset.

It is elementary that in determining the net income derived from the operation of a trade or business, all operating costs and expenses allowable as deductions must be determined and deducted from the gross income. The consumption of trade or business capital represented by depreciation is an operating cost the deduction of which in computing net income is specifically provided for in the Internal Revenue Code and several prior Revenues Acts, as follows:

Depreciation. A reasonable allowance for the exhaustion, wear, and tear of property used in the trade or business, including a reasonable allowance for obsolescence.

The factors of wear and tear and decay cause physical exhaustion, or deterioration, ultimately resulting in retirement of the property, while those retirements due to obsolescence are caused by forces ordinarily unrelated to physical condition.

Obsolescence may be defined as the process of becoming obsolete due to progress of the arts and sciences, changed economic conditions, legislation, or otherwise, which ultimately results in the retirement or other disposition of property. As said by the Supreme Court in *United States Cartridge Company* v. *United States* (1932) 281 U.S. 511, 516, Ct.D. 460, C.B.XI-1, 282, 283 (1932): "Obsolescence may arise from changes in the art, shifting of business centers, loss of trade, inadequacy, supersession, prohibitory laws and other things which, apart from physical deterioration, operate to cause plant elements or the plant as a whole to suffer diminution in value."

With respect to any property for which past experience indicates a gradual lessening of useful value due to inadequacy or obsolescence and when the effects of such factors can be expected to continue without substantial variation, the annual diminution in useful value is considered ordinary or normal obsolescence to be included in depreciation. Much of the discussion hereinafter having specific reference to depreciation only is in fact equally applicable to normal obsolescence.

Some property, however, may become obsolete or inadequate due to

* This bulletin also contains extensive tables of average useful life (years) of a wide range of capital assets.

revolutionary or radical changes unforeseen and unpredictable by their nature when the property was acquired. To distinguish from the allowance for what is considered normal obsolescence, this type is usually termed extraordinary or special obsolescence, allowances for which will be dealt with more specifically hereinafter.

BASIS FOR ALLOWANCE OF DEPRECIATION AND OBSOLESCENCE

The basis for computing the amount deductible on account of depreciation and obsolescence of property acquired after February 28, 1913, is, in general, the cost of such property. If the property was acquired by the taxpayer prior to March 1, 1913, the basis is, in general, the fair market value as of that date or its cost, whichever is greater.

In respect of property acquired by gift or transfer in trust; property transmitted at death; property acquired upon an exchange; property acquired in a reorganization after December 31, 1917; property acquired after December 31, 1920, by a corporation in exchange for its stock where immediately after the transfer the transferor of the property is in control of the corporation; property acquired by an involuntary conversion; property acquired during affiliation; and property acquired in corporate liquidations, the basis is governed by provisions of Section 113 of the Internal Revenue Code, as amended. For further information in this connection reference should be made to Appendices A and B.

To the cost or other basis of the property there should be added, when acquired or completed, the cost of additions, improvements, and betterments, and from it should be deducted the cost of all property when retired, abandoned, sold, destroyed, or otherwise disposed of. The cost of installation, as well as the freight charges thereon, are capital expenditures to be added to the cost of the property recoverable through depreciation deductions.

In the case of the acquisition on or after March 1, 1913, of a combination of depreciable and non-depreciable property for a lump price, the capital sum to be recovered through depreciation allowances is limited to an amount representing under all circumstances a reasonable allocation out of the total cost of all the property to that portion of the property subject to depreciation.

ALLOWANCE FOR DEPRECIATION AND OBSOLESCENCE

The proper allowance for exhaustion, wear, and tear, including obsolescence, of property used in trade or business is that amount which should be set aside for the taxable year in accordance with a reasonably consistent plan (not necessarily at a uniform rate) whereby the aggregate of the amounts so set aside, plus the salvage value, will, at the end of the useful life of the property in the business, equal the cost or other basis of the property. In no instance may the total amount allowed be in excess of the amount represented by the difference between the cost or

other allowable basis and the salvage value which reasonably may be expected to remain at the end of the useful life of the property in the trade or business.

The allowance in any given year must be determined in accordance with the conditions existing at the end of the year, and a taxpayer is not permitted under the law to take advantage in later years of his prior failure to take any depreciation deduction or of his action in taking deductions plainly inadequate under the known facts in prior years.

PROBABLE USEFUL LIFE – RATES OF DEPRECIATION AND OBSOLESCENCE

In General. The amount of the annual deduction allowable for depreciation is ordinarily dependent upon the expected useful life of the asset. The factors which determine the useful life of property in a trade or business have already been discussed briefly in the Introduction. These factors are wear and tear and decay or decline from natural causes; and also various forms of obsolescence attributable to the normal progress of the art, economic changes, inventions, and inadequacy to the growing needs of the trade or business. Two principal forms or types of obsolescence are generally recognized, that is, normal obsolescence and extraordinary or special obsolescence.

Normal obsolescence is caused by factors which can be anticipated with substantially the same degree of accuracy as other ordinary depreciation factors, such as wear and tear, corrosion, or decay. Accordingly, it is included in estimating the normal useful life of depreciable property, the effect of which is to include the allowance for normal obsolescence in the depreciation deduction.

Extraordinary or special obsolescence rarely can be predicted prior to its occurrence. However, this does not necessarily imply that the asset already must have been completely discarded or become useless, but merely that a point has been reached where it can be definitely predicted that its use for its present purpose will be discontinued at a certain future date. Deductions for obsolescence of this type may be taken over the period beginning with the time such obsolescence is apparent and ending with the time the property will become obsolete. In every case the burden of proof is entirely upon the taxpayer to establish a claim for obsolescence by facts and evidence that are definite and indisputable. No amount may be charged off in any year because, in the opinion of the taxpayer, property may become obsolete a number of years later. The allowance will be confined to such items or such portion of the property on which obsolescence is definitely shown to be sustained, and cannot be held applicable to an entire property unless all portions thereof are affected by the conditions to which the obsolescence is found to be due. Nor can obsolescence be allowed retrospectively in the light of subsequent events or happenings not anticipated during the period for which the obsolescence is claimed. In no case may the deduction for obsolescence be extended to include shrinkage in value due to other causes, as, for instance, a general drop in the price of commodities.

Past experience, which is a matter of fact and not of opinion, coupled with informed opinion as to the present condition of the property, and current developments within the industry and the particular trade or business, furnish a reliable guide for the determination of the useful life of the property. Such a determination should reflect all the peculiar circumstances of the use or operation of the property, such as the purpose for which it is utilized, the conditions under which it is used or operated, the policy as to repairs, renewals, and improvements, and the climatic and other local conditions.

X

PRINCIPLES OF EXPENSE CLASSIFICATION

IT IS WITHIN THE MEMORY of many of the older generation that a businessman after taking inventory at the end of the year and adding his expenses was not until then able to learn if expenses were less than income and what if any profit was made during the past year. Due to the work of accountants and industrial engineers in the field of cost accounting, expense control, and the economics of the business process, due also to the use of various tabulating and computing machines that have fundamentally improved the conditions of clerical work, the modern businessman has now available to him a vast fund of knowledge and wealth of techniques concerning the expenses of all types of business enterprise. Through this knowledge of the nature and character of the expenses of all phases of the business process from financing operations to marketing the product, the businessman can not only keep himself currently informed about the expenses of his business but he can estimate the probabilities of the expenses of a proposed undertaking.

I. CATEGORIES AND CLASSES

One of the basic steps in establishing a knowledge of expenses and providing a technique for their control is the establishment of categories and classes of expenses. Upon such categories and classes, the system of accounting is designed so that every penny of expense may be properly accounted for in accordance with the purposes and needs of the business. Accounting for expenses for profit estimating purposes is, of course, only one of the problems encountered in both large and small businesses. In addition, businesses of moderate and substantial size face two other problems of expense accounting which the small businessman does not find too difficult to handle and these problems are: (a) the determination of the cost of a product or a process, and (b) the measurement of each executive's efficiency.

It is comparatively easy in a small shop manufacturing one product only to find the cost of each unit produced. The unit cost in such a case is equal to total expense divided by the total number of units produced.

In such a business, there will usually be one or, at most, a few executives who keep constantly in touch with each other. Each of them is well acquainted with the others' activities, being probably able to interchange places if need be. There is no problem of "measuring" each executive's efficiency.

The situation is entirely different in large, modern industrial corporations or even in middle-sized businesses manufacturing several lines of products and managed by a substantial number of executives.

Let us take, for example, a middle-sized business which has two plants and a central administrative office, and manufactures bicycles in one plant and typewriters in the other. Should the telephone bill of the headquarters be considered as a cost of manufacturing the typewriters or as a cost of manufacturing bicycles or partly one and partly the other—but, then, in what proportion?

Let us take again the same business. The profit and loss statement shows a profit. Does this mean that Mr. Smith, the chief of maintenance in the bicycle plant, could not spend less money? How can we know?

Some expenses are obviously incurred in the manufacturing of bicycles, while others are obviously special to the manufacturing of typewriters. They can be directly assigned to each line of product. Such are raw material expenses, for instance, or parts bought from a contractor—the tires and tubes of the bicycle, the ribbons of the type-

writer. But even for them, or at least for many of them, the question of responsibility arises. If, for instance, fifty tubes a week are punctured while being mounted, should this waste not be charged to Mr. Thompson, who happens to supervise the department where tubes and tires are mounted on the wheels?

Other expenses are even more difficult to handle. A salesman may sell both bicycles and typewriters. His expenses must be allocated to each line of products. Also, the selling expense cannot be considered only as a whole since the sales manager for the West Coast district would not want to be held responsible for total sales expenses, including expenses of the New York district and of many others over which he has no authority.

Such examples show the complexity of determining the cost of a given product delivered to the customer and of measuring an executive's efficiency.

Cost accounting endeavors to solve such problems. It is not intended to enter here into the details of modern cost accounting technique, but only to give general guiding principles in the two main steps of cost accounting, namely, expense classification and expense allocation. The present chapter deals with expense classification, the following one with expense allocation.

Every classification is arbitrary, and has no meaning in itself. Its only value is in its final purpose. A paper manufacturer will classify his products according to their quality and weight because his purpose is to sell each quality at a certain price. The same sheets of paper, after they have been used for writing letters or printing books will again be classified but according to entirely different standards, such as, name of the author, content of the letter, size of the book, etc. Each standard of classification is justified if and when it serves well its own purpose. None is perfect, because every classification implies the preference given to certain characteristics, thereby ignoring other characteristics which, usually, have also their importance. If letters are filed according to the names of the authors, it will take time and effort, later on, to find those concerning a given subject, or referring to a certain period, or to a certain geographical district, etc. One solution is to file one copy of the letter alphabetically, one chronologically, one logically, etc. But practical considerations prohibit the extensive use of such a solution.

Expense classification does not escape the limitations of all classification, in that it also is arbitrary and far from perfect. It may be improved by refining, but refinements in cost classification are also

limited by practical considerations. The experience of many businesses shows that it is useless to recommend a cost system that will cost more to operate than the money it can possibly save.

Since conditions vary with each business enterprise, it is impossible to say, in general terms, how refined a cost classification should be. In this chapter we will study the generally accepted classification of expenses into *manufacturing expense, selling expense, administrative expense,* and indicate in what directions refined sub-classifications can be and, in fact, are attempted.

As a general introduction to the subject, it may be said that expense classification, just as every other classification, has no other meaning than that of its purposes. We must continually remind ourselves that the ultimate purposes of expense classification are:

1. To determine the cost of a product or process
2. To measure executive efficiency.

An expense classification that does not serve one or both of these two purposes is unjustified. An expense classification that, directly or indirectly, costs more to operate than the money it is intended to save is unjustified.

II. MANUFACTURING EXPENSE

There are three principal divisions of effort in the manufacturing industries, and these are:

1. Manufacturing the product
2. Selling the product
3. Administering the business.

To these divisions of effort correspond the generally accepted, and practically useful, functional divisions of expenses in:

1. Manufacturing expense
2. Selling expense
3. Administrative expense.

The manufacturing expense is the expense incurred during the third phase of the economic flow chart (conversion by manufacture).*

The economic flow chart outlined in Chapter I shows that for the manufacturing industries there is a flow of values in the third phase (conversion by manufacture) which results in the value of the prod-

* See Figure 1, page 11.

uct. It also shows that the flow is along three main channels: equipment, materials, and services.

How the "values" in equipment, materials, and services flow into the "value" of the product can be understood by examination of the nature of this value conversion process. The equipment used in manufacture consists of buildings and machinery and may be considered as permanent in the sense of use for a long continuing period of time. This equipment, such as a particular machine tool, may be used for a productive operation such as grinding or milling. Other equipment, such as used in the factory office (furniture, typewriters, etc.) and in the power plant (boilers, generators) and in other service departments, finds its use value reflected in the cost of the service in which it is employed. The values which flow through the materials channel are reflected in the cost of the material of which the product is made. Other materials used in the service departments find their values in constituting part of the service costs.

The values which flow into the product through services consist in general of:

1. Labor at productive operations
2. Labor in service departments
3. Power, heat, and light
4. Other service subsequently stated in more detail.

For purposes of accounting for, or measuring the flow of values to any particular product, it is generally convenient to group the elements of the conversion by manufacture into certain functional groups as items of cost, which will now be defined.

1. THE ITEMS OF MANUFACTURING EXPENSE

A. *Materials Cost.* This is the cost of the material which enters into and becomes part of the product. This is to be distinguished from the cost of those materials which are consumed or used during the manufacturing operations, such as oils, waste, taps and dies, coal, water, gas, etc. The cost of these materials is not part of materials cost, but is an item of factory expense to which reference is made late.

It may be asked, however, what constitutes the items of this cost, for, unless this is known, the term is still inexact. The cost of materials consists of the purchase price, plus freight and trucking charges incurred in conveying them from the place of purchase to the storeroom in the factory. This is the real cost of the material. However, it

is not always convenient to apply freight and handling charges to specific materials, particularly when freight, express, and trucking bills include miscellaneous materials delivered. Accordingly, materials cost, for practical purposes, is often taken as the purchase price, and the handling charges are listed as items of the factory expense.

While this method of determining the cost of materials is not strictly accurate—for, in reality, the cost should be based on all items of expense incurred in bringing materials to the point of use—at the same time, the additional expense of clerical service necessary to the allocation of freight and express charges may not be warranted. If, however, such charges can be easily determined, it is well to include them as items of the cost of specific materials. Sometimes such charges will be added in the form of "standard costs" to avoid the difficulty.*

Another and even more fundamental difficulty arises when the "purchase price" is considered. If a plant carries a substantial inventory of raw material, and if it takes a substantial length of time between the time the raw material is purchased and the time it is processed, the purchase price of the raw material being processed may be difficult to determine, because of the possible fluctuations on the commodity markets.

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* In its annual report to the stockholders for the year 1946, the Westinghouse Electric Corporation describes in detail its extensive use of "standard costs." As this description is of general interest, it is reproduced hereunder for the benefit of the reader. (This description is also related to the use of standard cost in the evaluation of labor cost and factory expense, which are discussed in the following pages.)

Basis of valuation: The majority of the material is priced at standard cost, which cost is based upon the average purchase price or estimated market price over a period of one year or longer; other material is valued at actual cost. Material price variation reserves are provided to adjust standard cost to actual cost. Where adjustment to replacement market value is necessary, the gross value of each class of inventory is adjusted to that value.

Under the companies' accounting policy the direct labor cost is based principally upon allowed standard time limits for performing processing operations, valued at normal standard hourly labor rates; other labor is valued at actual cost. Direct labor variations from standard are absorbed in operations currently.

Under the companies' accounting policy the indirect manufacturing cost is based upon costing rates per allowed standard time limits which, under normal productive activity, are intended to absorb fully the indirect manufacturing expenses, including depreciation, under normal operating conditions. The variation between the amount of indirect manufacturing expenses charged to inventories in accordance with said standard time rates and limits, and the actual indirect manufacturing expenses, is charged or credited currently to the cost of goods sold, except that a reserve is provided for that portion of the expenses over-absorbed and included in inventory values due to factory operations being above normal.

Shall we say that the "purchase price" of the material being processed will be, for accounting purposes, the average of the actual prices paid for the various lots of material that have been purchased during a given period—the year, for instance?

Or shall we say that we will assume that the material bought first is being first processed?

Or shall we, on the contrary, assume that the most recently purchased material is being first processed?

Or shall we endeavor to identify the raw material used and to assign to each lot manufactured the actual purchase price paid for the material actually used?

In fact, all those methods are being used by business. Some of them are readily accepted by the tax administration, some only upon approval of the Commission of Internal Revenue, and therefore sometimes used for internal purposes of the business only. They are respectively known by such names as the "Average Cost," "First-In, First-Out" (FIFO), "Last-In, First-Out" (LIFO), or "Identified Lot Cost" methods of inventory valuation.

For a detailed study of the question, the reader is referred to textbooks on cost accounting and controllership.*

B. *Labor Cost.* This consists of the wages paid to those workmen who are engaged in specific productive operations or who are in control of specific processing operations. The wages paid to the workmen operating a milling machine or a band saw or a power hammer, for example, are labor cost. The wages paid to toolmakers, storekeepers, and others who render important service in the factory are not labor cost but part of factory expense or factory overhead. The reason for this distinction is that the labor applied to specific units of work bears a direct relationship to the number of units of work accomplished within a given time period, and therefore the cost of such labor is a prime factor in the unit cost of production. On the other hand, the cost of service labor cannot be directly associated with the quantity of a specific unit of product manufactured during a given time period, and it must be accounted for by methods of indirect association with the work of production.

Labor cost is sometimes termed *direct labor,* and the wages paid to these rendering general service in the factory are frequently specified as *indirect labor.* The term productive labor is also used for direct labor; and non-productive labor is synonymous with indirect labor.

* See also "Inventory Pricing," Accounting Research Bulletin # 29, American Institute of Accountants, July, 1947.

Non-productive labor, however, is not a good term, because it implies that such labor is in the nature of a necessary evil, whereas it is, in fact, frequently the most important and useful labor in the sense of effecting a low cost of production.

C. *The Prime Cost.* This item is the sum of materials cost and labor cost.

D. *Factory Expense.* The total of all expense, other than materials cost and labor cost as above defined, incurred in the *possession* and *operation* of the factory comprises this item. It does not include the expenses of selling or managing the general affairs of the business. The possession of the factory occasions the expenses of taxes, insurance, and depreciation. The operation of the factory requires the services of management, supervision, storekeeping, cost keeping, toolmaking, boxing and crating, and many others, and also incurs expense for heat, light, and power. A list of factory expense items would therefore include:

1. *Indirect Materials.* In the operation of every plant, quantities of material such as oil, waste, brooms, files, belting, and other supplies are used; furnaces must be relined, boilers retubed, broken windows glazed, and the general "housekeeping" of the whole plant looked after. The cost of these materials, worn out or used up in the operation of the factory, is not specially associated with any definite product or process, but the expense is necessarily incurred by the operation of the plant as a whole, and is spread over all processes and products.

Sometimes it is convenient to group indirect materials costs under several different heads, in order that the whole cost of any service department, as distinguished from a processing department, may readily be determined. All indirect materials used in the power plant in its maintenance and repair might be listed as materials costs, power plant maintenance; whole materials used in repairing the building may be listed under the item of building maintenance. Accordingly, any detailed operating statement will usually not show all indirect materials cost under a single heading.

2. *Indirect Labor.* Two general classes of labor are employed in a factory: direct labor employed at productive processes, and labor employed in the service departments. Such labor may be skilled or unskilled. Indirect labor employed in the toolroom, for example, will be skilled—sometimes more highly skilled than the direct labor employed in processing. But it is not generally possible to associate the wages paid to the men in the toolroom with particular products being

made in the plant, because the results of their work are so broadly applied to factory output as a whole. The labor employee in moving materials about the plant is unskilled and indirect. Checkers, inspectors, timekeepers, and all others whose duties lie in similar fields are employed in so-called "service" departments, and their labor is all indirect. Like the analogous costs of indirect materials, the cost of indirect labor may not appear in the operating statement as a single item, but may be associated with a number of separate departments of operation or service, according to convenience or usefulness in management.

3. *Power, Heat, and Light.* All costs incurred in the provision and maintenance of this class of service are chargeable to factory expense, and will include wages paid, fuel consumed, and such items as insurance and depreciation, just as if the power plant were a separate industry by itself. Practice in accounting for the cost of power, heat, and light varies considerably. Sometimes insurance and depreciation are not included, but appear under the general heading of insurance and depreciation for the entire plant. Therefore it is always necessary, in comparing the power costs of different plants, to know how these costs have been itemized. Sometimes it is good practice to omit insurance or depreciation from the accounting of specific service departments, such as the power plant, and include such items in the accounts of the factory as a whole. The point is: When such is the case, be sure to *know* it when making any study of the situation.

4. *Insurance.* This is a service rendered by society. People contribute to a common fund for the purpose of helping one of the group who may suffer misfortune through fire or other calamity. The cost of this service is a factory expense due to the possession of the factory itself.

5. *Taxes.* The service rendered by the community to its members is paid for by taxes. Protection against fire, police protection against theft and riot, and other municipal services are paid for through taxes. This is properly chargeable to the possession of the factory.

6. *Depreciation.* All wear and tear of machinery and buildings must be charged to factory expense, since it is caused by the possession and operation of the factory, and is just as much a cost of producing an article as the cost of the material of which it is composed, or the labor employed in shaping it.

7. *Service Department Costs.* The departments of operation of a factory may conveniently be divided into processing departments and service departments. Toolrooms, storerooms, shipping and receiving

departments, drafting rooms, shop offices, yard gangs, pattern shops, etc., are all service departments; and the costs of operating these various activities are chargeable to factory expense. The *factory expense* is sometimes termed the *factory overhead* or *factory burden.*

8. *Factory Cost or Cost of Manufacture.* This is the sum of materials cost, labor cost, and factory expense. In preparing the profit and loss statement, the accountant often reports this item as the *cost of sales,* meaning thereby the cost of manufacture of the goods sold.

The classes of cost defined so far account for all those incurred in *manufacturing a product* and preparing it for shipment, ready for delivery to the customer. To obtain a clear picture of how these cost items accumulate as a product is being manufactured, we must examine more closely a typical manufactured product and trace the progress of its parts through a typical factory. For purposes of illustration we will select a mechanical product such as a lawnmower and consider what happens in the manufacture and assembly of its parts.

2. THE MANUFACTURE OF A MECHANICAL PRODUCT

In the first place, we find that the product consists of many parts. Some of these parts, such as bolts, gears, keys, and rubber tires may be purchased as finished parts from other manufacturers. The remaining parts are produced from raw materials. Each part must pass through a series of processes of milling, drilling, grinding, or other operation to convert it from raw material to a finished part. The finished parts must be assembled. This may proceed by assembling certain parts belonging to a unit of the machine and then assembling these units to form the complete machine. The problem posed in cost finding is to determine how much it costs to perform each operation on each part, how much it costs to assemble the parts into units and how much it costs to make the final assembly of several units into the completed product. Let us now look at the factory. Here we find that some of the parts are processed by the use of very costly machine tools while other parts are worked on at a bench with hand tools. A given part may start in Department A, for example, which is very costly to maintain; next to be worked on in Department B, which does not cost very much to operate; and eventually be finished in Department C, which again is costly to operate. The wage rates, the costs of power, tool service and inspection, to mention a few items, may vary among the departments. If, then, the increments of cost which a given part accumulates as it moves from department to department on its way to final form, are to be determined, it appears that the factory

expense must be determined for each department of manufacture. This means that the total of the factory expense for the entire factory must be considered as made up of the sum of the factory expenses of the departments. It also appears that some method must be found for recording the labor cost on each part as it is worked on in each department. The net result of these observations is that each department of manufacture must be dealt with as though it were a miniature factory and all the costs of operating each miniature factory must be assessed to the parts which pass through it.

This will enable us to know the total cost of manufacturing the product. At the same time, it will also enable us to determine the actual expense for which the heads of each of these miniature factories are responsible.

There is another aspect of the organization of a factory which needs to be understood if a clear picture of the problems of finding the production cost of a given product is to be had. Upon visiting a factory we find that it is organized on the basis of production departments and service departments. The productive departments may consist of:

a. A foundry for making castings of parts, later on to be machined
b. A milling department where all milling operations are performed
c. A drilling department where all drilling and tapping operations take place
d. A lathe department where turning operations are performed
e. A plating department where parts are electroplated
f. A polishing department where parts are polished after plating
Etc., etc.

In a small factory, Departments b, c, and d, listed above, may be combined in one department for general machine work. In a large factory, the productive departments may be organized on the basis of products made, and again subdivided into smaller components such as a department for the manufacture of complete parts of a given kind such as armature winding in a factory, manufacturing motors, or a department in which all armature and field coils are impregnated and baked. However the production departments may be organized either in a small factory or a large one, there will always be found a number of service departments organized to render service of a particular kind to all the production departments.

Such service departments may be:

a. A storeroom or a series of storerooms for raw materials, parts partly processed, and for furnished parts and complete products

b. A toolroom where all special tools, gauges, and fixtures are made and kept in repair

c. A pattern shop where wooden or metal patterns are made for use in the foundry

d. A tool crib where the tools are stored and from which they are distributed to the production departments as needed

e. A scheduling and dispatching office where the flow of work through the shop is controlled

f. A drafting department where the parts are designed and blueprints are made for use in the production departments and for some service departments, such as the pattern shop and toolroom

g. An accounting department where cost records are kept

h. A purchasing department Etc., etc.

Furthermore, we find some service departments are used not only by the production departments but also by other service departments. The power plant, for example, furnishes heat, light, and power for all departments, both production and service. The accounting department, the purchasing department, and the office of the works manager serve both the production and service departments of the factory. There appears in this whole set-up an intertwining of the flow of values which seems at first to be impossible of detection. How may these many costs of running a factory be brought under control so that some reasonable accounting of their relation to the parts and final product may be made?

It is the factory expense element which seems to be the troublesome one, since the materials cost and the direct labor cost can be readily associated with the processes performed and the product made. The problem then is one of allocating the elements of cost—materials, labor, and factory expense—to the parts and final product, as will be studied in the next chapter.

III. SELLING EXPENSE

The expense of all activities which are engaged in marketing the products and promoting their sales, together with the costs of the supplies and equipments used in such activities, constitute the selling expense. The usual classifications for such expense are:

A. Salaries—executives, salesmen, other employees
B. Commissions
C. Advertising by radio, newspapers, catalogues, and other media
D. Office expenses for telephone service, telegraph, office supplies, clerical services, etc.
E. Promotion expenses such as entertaining, convention displays
F. Traveling expenses for sales solicitations, consumer contacts, etc.
G. Rent of offices, branch offices, display rooms, warehouses, etc.
H. Delivery expenses
I. Trade association expenses
J. Bad debts.

The classification of selling expense items, and their subclassifications for any particular business, is controlled by the purposes such classifications may serve in arriving at equitable allocations which (1) permit the determination of the expense of distributing the products to the customers in all territories and in all groups, and (2) enable the management to measure the efficiency of selling executives and of marketing procedures. Some indication of appropriate selling expense classification for a particular type of marketing situation was given in Chapter VII, page 157.

Other situations such as the marketing of machine tools or of books demand classification of the items of selling expenses based on the kinds of activities engaged in, and the general trade practices inherent in each type of market.

IV. ADMINISTRATIVE EXPENSE

The items of this type of expense usually include:

A. Salaries of the president, vice presidents, secretary, treasurer; except as such officers, a vice president for example, may be in charge of marketing or of manufacturing. (In the latter event salaries and associated expenses of their offices are usually classified under the departments they supervise.)

B. Salaries of all employees in administrative offices

C. Supplies and other office charges such as typewriter and accounting machinery repairs

D. Rent, insurances, taxes, heat, light, power chargeable to administrative quarters

E. Traveling expenses

F. Legal expenses

G. Financing expenses.

The division between administrative expense and selling expense is not always clear in certain types of expenditures. If, for example, the president of the company divides his time between general administrative duties and maintaining contacts with important customers with whom he may contract for their annual supply of the company's products, it is not always apparent how much of his salary and traveling and office expenses should be charged to sales or to administration. Many administrative officers and their staffs often divide their activities among the various divisions of the business with the result that the expenses associated with their activities can only be classified in categories which permit of periodic review as to their variation in time, that is, month by month. The items of administrative expense can not be identified with any of the processes of manufacture nor other prime activity of the business since there is no functional or cause-and-effect relation between such expenses and these activities. Who can tell, for example, what the economic effect of a discussion on manufacturing policy with the president of the company may have on the costs of production? Administrative expense items therefore are classified in such categories as will permit of periodic review of their variation from established patterns. The consequences of such variations are not usually measurable, and therefore the control of such expenses can not be reduced to the scientific accuracy which attends the control of other expenses such as manufacture, for example.

V. SUMMARY

The elements of the cost of manufacture are shown graphically in Figure 56.

To recapitulate, for convenient reference: The several elements of cost may be grouped as follows:

A. Materials cost—The cost of materials entering into and becoming part of the product as sold

B. Labor cost—The cost of labor which can be directly associated with a specific product or process

C. Factory expense—All costs other than direct materials and direct labor which are occasioned by the possession and operation of the factory

D. Selling expense—All expenses incurred in marketing the product

E. Administrative expense—All expenses incurred, other than manufacture and selling, in managing the general affairs of the business

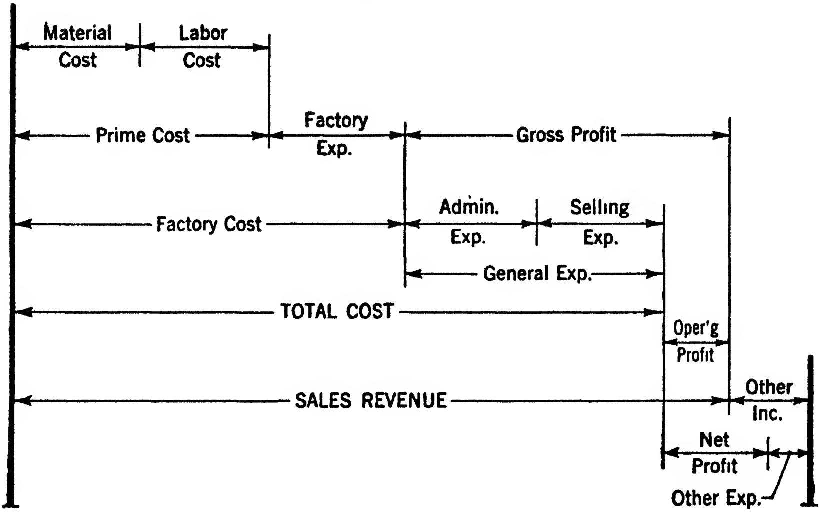

Figure 56. The Elements of Cost in Manufacture

Typical items of *factory expense* are:

1 Indirect labor
2 Indirect material
3 Superintendence
4 Heat, power, and light
5 Toolroom
6 Maintenance and repairs
7 Building and grounds
8 Insurance
9 Taxes
10 Depreciation

Selling expense includes:

1 Salaries
2 Traveling
3 Advertising
4 Conventions
5 Commissions
6 Telephone and telegraph
7 Supplies and postage

Administrative expense may consist of:

1 Salaries
2 Traveling
3 Legal
4 Telephone and telegraph
5 Supplies and postage

Prime Cost is the sum of materials cost and labor cost.
Factory Cost is the sum of prime cost and factory expense.
Total Cost is the sum of factory cost, selling expense, and administrative expense.

XI

PRINCIPLES OF EXPENSE ALLOCATION

EXPENSE CLASSIFICATION may be likened to the assembling of documents of like characteristics in one folder. Not until the folder is properly filed can it be said that the filing of the documents is completed. So also expenses after they are *classified* must be *allocated* in a properly designed system of cost accounting before the purposes of classification have been fulfilled. Such a properly designed system of accounting will provide that the same operation will allocate the expense to a product or a process (determining the cost of the product or process), and to a department or division of the business (determining executive responsibility and efficiency).

To illustrate this procedure, let us take the case of a business manufacturing four types of products designated by 1, 2, 3, and 4, and assume that there are five executives to be known as A, B, C, D, and E, who are responsible in their respective spheres for all the expenses of manufacture. The cost accounting system should provide for the

classification and allocation of all items of expense in such a way that the cost of each product is determined and the expenditures controlled by each executive are assembled. Each product's selling price may then be compared to its cost. The executives' performances may be measured and compared, and their efficiencies ascertained. Under such a system of expense classification and allocation, a tabular statement of the following nature may be set up (Table XLI).

TABLE XLI

COST ALLOCATION DIAGRAM

Product 1	Product 2	Product 3	Product 4	
A				Total Executive A
B				Total Executive B
C				Total Executive C
D				Total Executive D
E				Total Executive E
Total Product 1	Total Product 2	Total Product 3	Total Product 4	GRAND TOTAL

Each dollar spent in the business should be so classified and allocated that it eventually finds itself in one of the above spaces. By adding the figures in the spaces vertically, the cost of each product is found. By adding horizontally, the total expenditures made under the supervision of each executive are determined. The sums of the vertical and horizontal totals are equal to each other and equal to the grand total (cost of operation). It must be noted, however, that there are some expenses such as rent, depreciation, and taxes, which, for accounting purposes, are assigned to certain executive categories, although the executive can not be held responsible for their amounts. Accordingly, the spaces in the above diagrammatic presentation of the idea of classification and allocation must be further broken down so that the column at the right (executives' totals) will consist of two parts, one assigned expenses, and the other the amounts for direct labor, supplies, etc., spent under his control. It is this latter amount for which the executive is held accountable and which may be used for the measurement of his efficiency. Modern accounting practice provides for the break-down of expenses by executives as above described so that direct accountability for expenses under any executive's control may be required. This is necessary for purposes of budgeting.* *The*

* This problem will be developed in the second of this series of books: the one on managerial control.

above pattern of expense allocation is intended to illustrate simply and diagrammatically the general problem of allocation organization, and is not intended to create in the reader's mind the dangerous illusion that the treatment of expense data is simple and the problems of production cost and executive efficiency are easily solved. On the contrary, it should be clearly understood that the matter of cost accounting is one of the most complex faced by industry. It is not intended here to do more than to develop a few general principles that may serve as an introduction to a study of cost allocation.

I. PATTERN VARIATION

The application of such principles will indeed vary with the type of business under consideration, as the example used for illustration, taken from practice, will clearly show.

There are, in general, three types of business distinguished by the character of their processes of manufacture or the character of their business activities. These are:

A. The process industries
B. The materials fabrication industries such as machine shops
C. The compound businesses, such, for example, as those which both manufacture equipment and contract for the installation of such equipment, and also sell it to others who do the installing.

A. THE PROCESS INDUSTRIES

In these businesses, the manufacturing divisions of which consist in the processing in bulk of given raw materials such as sugar, paper, cement, yeast, leather, glass, and like products, it is necessary to know the costs of each process or each group of like processes in order to devise effective economic control of production as a whole. Unless costs by processes are ascertained, it will be impossible to locate the causes of the rise or fall of expense in any given period compared to a prior period. Therefore, the correct determination of costs by processes is important in such industries. Direct material costs are easily determined for such industries. Direct labor does not have the significance it has in the metal-working industries, where economy of production is in some measure dependent upon the efficiency of labor itself, and upon the management of such labor. Accordingly, the direct labor item is not determined by the direct labor timecard method, but is associated with the processes at which the

labor is engaged. In this respect it is handled like any item of factory expense.

It will also be noted that direct labor has not the same control on output as it has in some other industries. When labor is required to attend an operation which is conducted for, say, six hours, at a temperature of a given amount, there is nothing labor can do to hasten or delay the operation. Furthermore, the wages paid to labor are applied to the same material batch after batch (if the batch method of operating is used), or to the whole material produced in the period of operation.

The accounting for labor costs is accomplished by direct apportionment to the process at which it is employed. The factory expense, however, presents a different problem, for it is not usually apparent how much power, steam, water, gas, or other items of factory expense are consumed or occasioned by one process or another. It is only after a careful analysis based on measurements that any reasonable apportionment of factory expense to processes can be accomplished.

The first step in such an analysis is to prepare a *flow sheet* of the processes. This is a statement, usually in graphic form, of the sequence of primary processes, together with those companion thereto, through which the materials pass from the raw state to the finished product.

The next step is to block out, on the floor plans of the plant, the space occupied by each process, and identify each piece of machinery and equipment used in conjunction therewith.

The third step is to determine the amount of fixed charges, such as depreciation, insurance, and taxes, associated with each process, and the amount of proportion of variable charges, if they are applicable to several processes, which each process occasions. The mechanism of the accounts may then be set up so that the total factory expense in any month may be apportioned to the proper processes. Monthly comparisons of these costs and the details thereof will then reflect the influence of changes in operation conditions or policy, and thus serve in the guidance of future operations. The chart shown in Figure 57 illustrates a graphic record of process charts used by a writer in operating a certain business. The processes are subdivided into two different groups and are itemized on the right edge and left edge of the chart. The heavy lines measure, by their length, the total production cost per pound of product for the month; the light lines on each side of the heavy line represent by their lengths the process costs. The chart also gives the standard costs, that is, the predicted costs

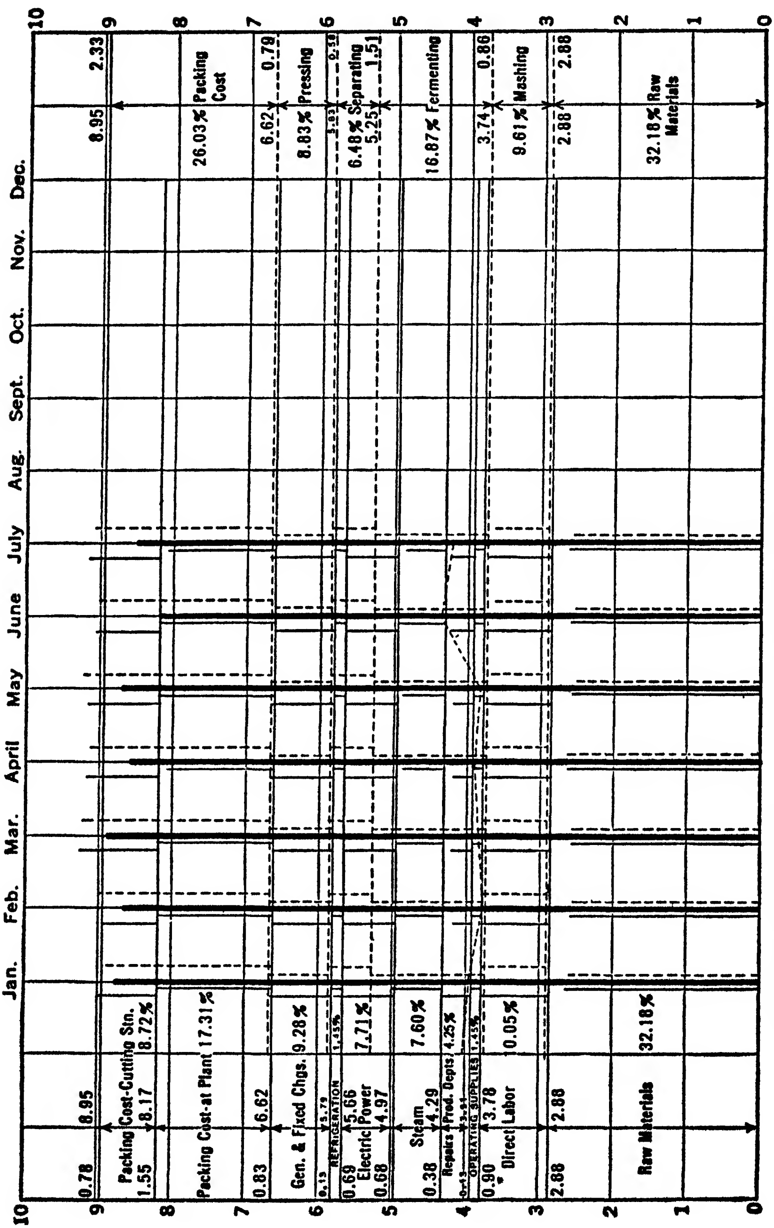

Figure 57. A Graphic Method for Recording the Costs of Processing

per pound of product as well as the predicted cost per pound for each process.

B. THE MATERIALS FABRICATING INDUSTRIES

Industries such as machine shops, are sometimes referred to as mechanical manufacture. Such plants, in general, may be regarded as made up of two classes of departments. One class of departments in metal-working plants, for example, consists of machine shops, foundries, and assembly shops. Such departments or shops are engaged in forming or shaping or otherwise treating the product. In this sense they may be termed *productive departments.* Other departments exist to render service to the productive departments. Such departments are toolrooms, pattern shops, power plants, repair shops, etc. These may be termed *service departments.* When the productive departments are quite different in character, and when all the products do not pass through all the productive departments, it becomes necessary to treat each productive department as if it were, in a sense, a separate manufacturing plant. This demands that each productive department must carry a separate factory expense. Accordingly, therefore, it must be determined to what extent, from the standpoint of expense, each service department serves each production department and also what amounts of factory expenses such as taxes, insurance, depreciation, and other items are directly incurred by each production department.

C. COMPOUND BUSINESSES

Very frequently the business of a company involves not only the manufacture of machinery, equipment, or materials, but also the installation of the machinery or equipment, or the application of the materials to construction work. Under such circumstances the company is engaged in both manufacturing and contracting. It very frequently happens that such companies not only contract for the installation of the machinery or materials which they manufacture, but they also sell their products to others, who in turn act as contractors for such installations. A manufacturer of composition flooring materials, for example, may also take contracts to lay floors in hospitals, office buildings, and public buildings, in the community in which the factory is located, as well as sell the products of the factory to flooring contractors in distant cities.

Manufacturers of small ammonia compressors for refrigerating purposes usually take contracts for the installation of small refrigerating plants and, therefore, maintain a force of men for the installation of equipment over a considerable territory. For this purpose, also, the manufacturer may operate a "pipe shop" to make the coils and condensers which together with the compressors constitute the principal material for the installations. He may also sell his compressors through resale agents who have their own "pipe shops" and take contracts for installation.

Manufacturers of fabricated steel for building purposes, particularly for building alterations and extensions, so many of which exist in and nearby our larger cities, frequently maintain a warehouse of structural shapes from which they withdraw materials for use in their own fabricating shop, on contracts which they have taken, and from which they also sell structural shapes to builders who cannot afford to carry a large inventory of steel shapes. The owners of such an enterprise may be in the fabricating business, the warehousing business, and the contracting business.

A certain well-known manufacturer and distributor of watches produces in his own plant only 40 percent by value and 20 percent in number of the watches sold by the company. His principal business is, therefore, the merchandising of watches. Any number of similar examples might be given in illustration of the fact that many business enterprises, though apparently manufacturing, are in reality based upon or concerned with other operations as well. They are, therefore, essentially "compound businesses" conducted by a single organization. Any analysis of the economic characteristics of such a business as a whole must be based upon an analysis of the economic characteristics of each component thereof. In like manner the economic operation of a power plant as a whole can be accomplished only by a proper control of each unit of the plant, and this control can be effected only when the performance characteristics of each unit are understood.

Example

The procedure to be followed in the subdivision of factory expense and general expense on the basis of the character of the business, for the refrigerator business referred to above, may serve as a typical example from which a set of principles may be deduced. This business involves the following operations or activities:

1. Manufacture of compressors and auxiliary parts
2. Manufacture of coils and condensers
3. Purchase of equipment, such as motors, belts, etc., for use on contracts

4. Contracting for complete installations in which the company's own compressors and coils are installed, and for which motors, iceboxes, and insulation are purchased for installation

5. Sale of compressors to other contractors who install complete plants and who may operate their own pipe shops and purchase iceboxes, motors, etc., from other manufacturers or jobbers; or sale of compressors and coils to such resale agents who assemble the other equipment and install the plant.

A factory organization with a superintendent, cost clerk, payroll clerks, stores system, and all other necessary service departments is maintained to operate the compressor shop and the pipe shop. A materials procurement department purchases the castings and other raw materials for the compressor shop, the pipe shop, all supplies for the service departments, and all material for reshipment to contract installations.

The engineering department designs compressors, piping, and complete plants which the company installs on contract. The shipping department prepares shipments to contractors and to purchasers of compressors. The general office (executive department) directs the policies of all divisions of operation. Time is spent in formulating contracts for complete plants and in promoting modern methods of manufacture in the compressor shop and in the pipe shop and on other corporate problems and interests. The sales department is selling complete plants and also compressors to other contractors.

Thus it will be seen that many of the activities of the factory, office, and the administrative and sales departments, all of which occasion certain expense, are generally spread over the five divisions of operation or activities of the business. It is also apparent that resale agents who act as independent contractors are interested in purchasing compressors from the company at the lowest prices and the company is also anxious to sell these compressors at a low price commensurate with a reasonable profit, and thus meet competition and promote the widest distribution of its compressors.

Accordingly, therefore, the company must determine, with reasonable accuracy, the cost of manufacturing compressors as an independent enterprise. It would not be fair to charge the compressor manufacturing department with the whole expense of operating the materials procurement division, nor even a considerable portion thereof, because this division spends most of its time and energy in procuring materials for contract installation and only a small portion of time in purchasing and following up raw materials for the compressor shop. Nor would it be fair to charge all advertising and sales expense to contracts for complete plants, for then the compressors would be estimated at too low total cost and actual net profits on such sales would be less than estimated profits.

The pipe shop must also be treated as an independent enterprise, if coils and condensers are also sold to resale agents, and the total costs of its products determined on that basis. If other products are sold to independent erectors and also used on the company's own contracts, it is evident that the department in which such products are manufactured must be treated as an independent enterprise for cost-finding purposes.

Principles

A company operating a compound business must therefore have regard for the following principles:

1. All items of factory expense must be apportioned to the "independent enterprises" according to the responsibility of each.

2. The total of the *portions* thus found should constitute the total factory expense for each respective industry. Thus A percent of factory expense by the business as a whole is the factory expense of the compressor shop; B percent for the pipe shop; C percent for contracting and erecting department; and D percent for any other department there may be which sells goods to customers and to the company. $A\% + B\% + C\% + D\% = 100\%$ factory expense of the business as a whole.

3. All items of general expense must be apportioned to the independent enterprise according to the responsibility of each for the existence of such expense.

4. The total of the *portions* thus found should constitute the total expense for each respective industry.

5. The cost of compressors for delivery to resale agents must be the same as the cost of compressors for delivery to the company. Likewise for any product similarly handled.

In general, it may be stated that the foundation for determining the economic characteristics of any given business lies in the cost methods used for estimating the expenses incurred by the divisions of the business, by the departments (production and processing) of the business, and their proper apportionment to the products made or the processes conducted, as the case may be.

II. THE ALLOCATION OF THE PRIME COSTS

A. THE ALLOCATION OF LABOR COST

The cost of direct labor in mechanical manufacture is relatively simple to ascertain. In the smaller shops of the jobbing type, the material, after withdrawal from stores, is delivered to the productive department where the first operation on it is to be performed. Here the workman performing the operation records the number of hours he took to do the first operation, the number of units completed and the order number, say T531, against which his labor is to be charged. Such time-tickets are forwarded to the accounting department where the labor costs to perform the first operation on the lot completed and of each unit are computed. The same procedure is followed at each

of the succeeding departments. In this manner the labor costs of each operation and of the completed part are recorded. When the parts are assembled into the completed product, the labor cost of assembly is also charged to the shop order (No. T531) and thus the entire labor cost of the finished product is accounted for.

In large organizations, engaged in continuous manufacture, where the workers are usually paid on the basis of a group bonus, special procedures are in use to record the time spent by the group on a certain lot of production. But the principles involved are the same. They always involve a double allocation of cost:

1. To the product
2. To a department.

This double allocation corresponds to the double purpose of cost accounting:

1. Determining the cost of a product
2. Measuring the executive's efficiency.

B. THE ALLOCATION OF MATERIALS COST

In mechanical manufacture, as distinguished from the process industries, the parts of which the product is composed are each authorized for production in specified quantities by the issuance of a shop order. This order bears a number, or perhaps a number and a symbol or letter such, for example, as T531, and calls for the manufacture of, say, 100 units of a specified part. The first step in manufacture is the withdrawal from stores of the raw material from which the 100 units are to be made. As the material is withdrawn from stores, a record is made of the quantity withdrawn and the shop order (No. T531) against which the material is to be charged. This record is sent to the accounting department where the materials cost of the lot of parts (100) and hence of each part is to be computed. A means may also be provided for crediting materials costs with income from the sale of scrap, if such refinement in accounting serves a useful purpose in cost determination and control. In any event, the system of allocation of a given quantity of material to a specific shop order is comparatively simple and accurate.

Some attention, however, must be given to the problem of costing the quantities of materials withdrawn when such materials have been bought at different times and at different prices.* The cost clerk must

* See above, Chapter X, page 246, a summary of the various methods of inventory valuation currently used.

find from his "balance of stores" cards when the lots are received in stores and when the last quantity of each lot is finally issued, as he applies the different unit costs, if any. In those industries in which the prices of raw materials may vary widely at times, such as drugs and chemicals, the determination of the materials cost of production is often accompanied by more elaborate stores records than in those industries in which the materials costs are low and the price variations are not significant.

III. THE ALLOCATION OF FACTORY EXPENSE

A. ALLOCATION OF FACTORY EXPENSE TO PRODUCTION DEPARTMENT

Let us now examine the factory expense problem in some detail. In the first place, it will be noted that certain items of factory expense are found directly in the production departments. These include depreciation and repairs of machinery, foremanship, and some indirect labor and indirect material. In addition, it is not difficult to allocate to each production department a fair share of the expenses of building depreciation and repairs, of heat, light, and power, and of local taxes and the cost of special services rendered to the department in such matters as special tools. The above items of factory expense may be found for each production department by direct accounting methods.

In the next place, it will be found that some factory expense to be allocated to the production departments arises from the operations of the many service departments on which the production departments depend. The tool crib, the storeroom, the purchasing department, the drafting room, the inspection department, the scheduling and dispatching department, all render needed services to the production departments. The total expenses of operating each service department are generally ascertainable by direct accounting of wages and salaries, and heat, light, and power apportionment, etc. But how much of each total should be allocated to each production department is the important matter to decide. This must be done by indirect methods of accounting. In graphic form, the above problem of treating each production department as a miniature factory, the costs of operating which are to be determined, appears as shown in Figure 58.

The total costs of the services used in common are easily determined but, as the diagram shows, the "values" which are generated in each service department flow to all the production departments.

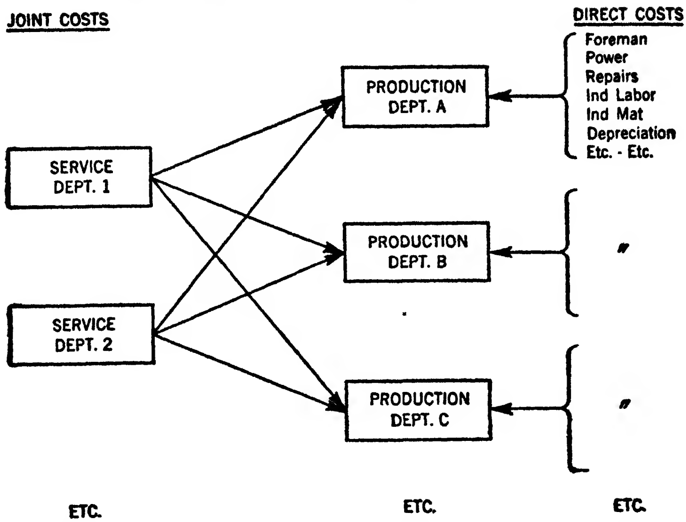

Figure 58. Pattern of Expense Allocation to Production Departments

but at different "rates" in each case. These rates are not so easily determined.

In symbolic form, the problem of determining the factory expense for each production department may be written:

$$E = D + (a)1 + (b)2 + (c)3, \text{ etc.}$$

E = Factory expense of production department
D = Factory expense items found by direct accounting
(a) = That proportion of the total expenses of operating service department (1) which is incurred by the Production Department in question.
(b) = Same for service department 2.
(c) = Same for service department 3. Etc., etc.

The following example from the writers' experience will illustrate the application of the above procedure.

Example

A certain factory, employing about 250 men and manufacturing several types of metal products of large and small size, found that its prices were out of line with those of its competitors. It therefore wanted an investigation of its processes and costs. While its processes could be improved, its principal difficulty as to pricing was in cost allocation. Its operations were

carried on through the following production and service departments. There were five production departments:

1. A machine shop for finishing iron and steel castings, bar stock, etc.
2. A brass machine shop for finishing brass castings which are cast in the company's brass foundry
3. A brass foundry
4. A brass products assembly department
5. An iron products assembly department.

There were the following service departments:

a. A pattern shop for making patterns for the brass foundry and for making patterns for brass castings which are purchased at various foundries in the neighborhood
b. A toolroom for the making and repairing, as well as for the care and distribution, of tools for the iron shop, brass shop, foundry, and assembly departments'
c. A power plant
d. A repair and maintenance gang for the upkeep of all machines and repair of buildings for all productive and service departments
e. An engineering department for designing all products manufactured and occasionally designing equipment and fixtures for some of the service departments
f. A storeroom for the custody of all raw materials
g. A stockroom for the custody of all finished products
h. A shipping department
i. A yard gang for general service
j. A general factory office for planning, supervision, and record keeping.

The problem was to determine, with a reasonable degree of approximation, the total amount of factory expense to be apportioned to each productive department in order that this expense might in turn be assessed against the products made in these departments.* To this end, it is convenient to set the problem in the tabular form shown in Table XLII.

The cost of operating each service department must be determined by an analysis of the items of expense which it incurs. The pattern shop may be taken as a typical example, for which the items of expense were:

1. Materials (direct and indirect)
2. Heat, light, and power
3. Insurance
4. Taxes
5. Labor, direct and indirect
6. Maintenance and repairs.
7. Depreciation, etc.

The probable magnitude of each of these items for any accounting period, say for one month, may be found as follows:

1. Materials—estimated from past records
2. Heat, light, and power—from inspection and test, as a result of which

* For the allocation of factory expense to the products, see page 271.

TABLE XLII

ALLOCATION OF FACTORY EXPENSE TO PRODUCTIVE DEPARTMENTS

Items of Factory Expense (*Monthly*)		Productive Departments				
Direct	Total	No. 1	No. 2	No. 3	No. 4	No. 5
1. Taxes	420	100	80	20	160	60
2. Insurance	710	200	110	80	90	230
3. Indirect labor	5,000	1,000	800	1,200	1,500	500
4. Indirect materials	5,000	800	500	1,700	1,000	1,000
5. Supervision	2,500	500	900	600	300	200
6. Depreciation	1,700	400	300	200	600	200
		Service Departments				
a. Pattern shop	1,500	500	500	500	...	...
b. Toolroom	3,000	300	1,000	700	1,00C	...
c. Heat, light, power	2,500	800	700	200	200	600
d. Maintenance and repair	1,600	300	200	500	400	200
e. Engineering and design	2,000	1,000	500	500	...	...
f. Rough stores	2,500	600	800	300	500	300
g. Finished stockroom	1,000	100	200	600	100	...
h. Shipping	1,300	700	600	...	...	...
i. Yard gang	4,000	800	600	1,000	1,200	400
j. Factory office	2,500	600	900	200	300	500
TOTAL	$37,230	8,700	8,690	8,300	7,350	4,190

it may be found that six percent, for example, of the entire cost of this item for the whole factory for the month is probably caused by the operation of the pattern shop

3. Insurance—from wages of employees for compensation insurance; from proportion of value of machinery and inventory to value of machinery and inventory of the whole plant for fire insurance: from area occupied to entire area of all departments for fire insurance on building

4. Taxes—from proportionate value of building and equipment of pattern shop and the whole plant

5. Supervision—from past records and inspection

6. Depreciation—from rates appropriate to each type of equipment.

The apportionment of the totals of the above items (direct and service department charges) to the productive departments may be made as follows: All the direct charges, with the exception of supervision, are determined separately for each department as indicated above. Supervision may be apportioned with reasonable accuracy on the basis of the number of direct labor employees engaged in each productive department to the total of such employees for all productive departments. The pattern shop may be assigned as an item of factory expense to the brass foundry and to the iron

machine shop in proportion to the average wages paid for work on patterns for the iron foundry and for the brass foundry, as shown by the records of past performance. Thus, if two-thirds of the wages paid are for patterns for iron castings, then the estimated total cost of operating the pattern shop will be apportioned two-thirds to the iron machine shop and one-third to the brass foundry. The total cost of operating the toolroom will be apportioned to the iron machine shop—and the brass machine shop on the same basis. The other productive departments will use the toolroom so little in comparison to the machine shops that it is within the degree of approximation to neglect them in this apportionment. However, if this should for any reason not be the case, then naturally that department which may require toolroom service to any considerable extent must be included in the apportionment.

Heat, light, and power must be apportioned to the productive department by test and inspection.

Maintenance and repairs cost for each productive department are estimated from past records.

Engineering and design are so broadly used by the productive department that it is not readily seen how they may be rationally apportioned to the several productive departments. In all probability, the apportionment will usually be approximately right if made on the basis of the ratio of the productive hours or direct labor wage in each productive department to the total of productive hours or direct labor wage of all productive departments.

Rough stores may be apportioned to the iron machine shop, brass machine shop, and brass foundry on the basis of the floor space occupied and the proportionate amount of labor employed in handling the stores of each of these departments. If purchased parts for use only in the assembly departments are also handled as a part of the rough storeroom and if also finished parts are withdrawn from this storeroom for the assembly departments, then these departments must also participate in the expense of maintaining the storeroom, and the participation may likewise be made on the same basis. It is not always apparent how the cost of maintaining the finished stockroom may be apportioned to the productive departments. In all probability, this had best be apportioned to the iron machine shop and the brass machine shop on the basis of the relative amount of expense in preparing and handling each class of shipments (iron products and brass products) and assigned to the iron machine and brass machine shop accordingly.

The cost of operating the yard gang in relation to the operation of the productive departments is not always apparent. Perhaps the best method of apportionment is by inspection of the work the yard gang does and estimating the probable responsibility of each productive department for necessitating this work.

All of the office expense may be apportioned to the productive departments on the basis of the relative average monthly productive hours anticipated for each productive department. It is true that some of the office expenses are incurred by the service departments and logically should be apportioned to the service departments. But it was found in this case that the result was about the same as if the apportionment were made direct to the productive departments, and hence the simpler procedure was adopted.

PRINCIPLES

The above type of procedure for determining the probable factory expense which will be incurred and should be allocated to each productive department is, in summary:

1. Classify the accounts or expenses in such manner that each type of expense may be summarized for each department of the business.
2. Assemble the expenses for the past year as incurred by each department, both productive and service. These may be averaged on a monthly basis if no change in operations is anticipated for the coming year. If a change is anticipated, such, for example, as an addition to the machine shop or installation of new furnaces in the foundry, then the expenses anticipated in such changes should be included in the estimates.
3. Apportion the expenses of each service department to the productive department according to the probable use which each productive department will make of each service department. The anticipated expenses directly incurred plus those apportioned from the service departments constitute the anticipated total factory expenses of the productive department.

Accordingly, the probable total factory expenses to be allocated to each productive department is found. It now remains to find some rational method by which each total may be assessed to the products flowing through each productive department.

B. ALLOCATION OF FACTORY EXPENSE TO THE PRODUCTS

The objective in this procedure is twofold: first, to assess to each operation, each part and each product its equitable share of the factory expense; second, to provide that the total factory expenses assessed will closely approximate the factory expenses incurred. Accordingly, the important question is: What is an equitable basis for assessing each operation, each part, and each product with its share of the anticipated factory expenses? Various methods are used, depending on the nature of the operations performed. The general principles of these methods will now be considered and illustrated by examples.

In the mechanical or metal-working industry, there are three general methods used for the allocation or distribution of factory expense to processes, to parts, and to products, and these are on the basis of materials, wages, or man-hours. In the process industries, the factory

expense is often distributed on the basis of either the quantity or the value of material output. Some process divisions, such as foundries, associated with the metal working industries use this method.

1. Factory Expenses Distribution by Materials

a. MATERIALS (VALUE)

A certain manufacturer finds that the following total costs of manufacture have been incurred on account of the products sold during the month:

Material	$20,000
Labor	10,000
Factory expense	10,000

It is observed that, for every dollar spent for materials, $0.50 was spent for factory expense. Accordingly, therefore, he estimates that any given part, let us say product A, incurring a unit materials cost of $3.00 and a unit labor cost of $2.00, has incurred a unit factory expense of $1.50, and that the unit manufacturing cost is therefore $6.50. Product B, on the other hand, required $1.00 worth of material and a unit labor cost of $2.00, and it is assumed to have incurred a unit factory expense of $0.50; the unit cost of manufacture is estimated to be $3.50. If this method of estimating is applied to all the products sold, it appears that the total factory expense will be accounted for, that is, the sum of all unit factory expense items assessed to each product will balance with the total factory expense.

b. MATERIALS (WEIGHT)

If, in addition to the value of the material, a record of weights or quantities is compiled, factory expense distribution by weight in quantity is possible. If a plant for any given month incurs a factory expense of $8,000 and there are 25,000 barrels produced, then the factory expense per barrel will be found to be $8,000 ÷ 25,000 = 32¢. In such factories, however, it may be found desirable to determine the apportionment of factory expense by processes in order to compare the economy of operations of each processing department from month to month.

In foundries producing a uniform style and weight of casting, the factory expense may be apportioned to the production for the month on the basis of the poundage produced. If, for example, the factory expense for the month for a brass foundry is $20,000, and 400,000 pounds are produced, the factory expense per pound is 5¢. A casting weighing 3 pounds would accordingly be apportioned a factory expense of 3 x 5¢ or 15¢. When, however, the foundry produces a wide range of castings, some of which may be very heavy and require intricate core work while others are comparatively light and require no core work, obviously each class of castings is not equally responsible for the factory expense incurred, and, therefore, a subdivision of factory expense must be made, applicable to each class of castings. That is, each class of castings will bear a predetermined proportion

of the factory expense. Suppose, for example, there are found to be three classes of castings to be designated as Class A, Class B, and Class C. A careful study of the operations attending the production of each class in the matter of factory expense involved may indicate that Class A occasions 50 percent of the factory expense; Class B, 30 percent; and Class C, 20 percent, when the ratio of poundage of each class produced to the total output is a given amount or lies between certain limits. Accordingly, if the total factory expense is $20,000 for a given month, all castings of Class A produced in that month should be burdened with 50 percent of $20,000, or $10,000, while all castings of Class B should be burdened with 30 percent of $20,000, or $6,000, etc. It is important to note, however, that, should the ratio of poundage of each class to the output be materially changed, then the percentages of factory expense to be applied to each class should also be changed. If the entire foundry is used to produce Class A castings alone, it is obvious that 100 percent of the factory expense should be incurred by Class A products.

Principles

It may be stated in conclusion, regarding the apportionment of factory expense by the percentage on materials methods:

1. That it is applicable to the factories producing bulk materials, such as sugar, soap, cement, castings, forgings, paper, pulp, paint, bread, yeast, and the like.

2. That when the final products, although the processes are common to all products up to a certain point, are of different styles or types, as in the foundry referred to above, the factory expense should be apportioned to the several styles or types of products after a careful analysis of the extent to which each is responsible for the factory expense incurred.

3. That the apportionment of factory expense as just indicated, since it is necessarily founded upon a given ratio of poundage of each style or type to the output of the plant as a whole, is no longer a correct apportionment when the ratios are changed to a considerable extent, and a reapportionment must be made, therefore, in order that a more accurate cost may be determined.

4. That in plants of the above type, it is useful to determine the proportion of the factory expense to be borne by each process or each group of related processes, and, therefore, the total factory expense should be apportioned according to processes or groups of processes on the basis of the responsibility of each in the incurring of the factory expense.

5. That the apportionment just indicated may be made by careful determination of the amount of power, heat and light, insurance,

taxes, indirect material, indirect labor, and other items of factory expense entering into each process or group of processes, and applied to the cost of the product on the basis of the poundage produced in the time during which the expenses were incurred.

6. That since some of the factory expense items (and sometimes a large proportion) are constant for the month, the factory expense per pound of product produced will vary in accordance with monthly production.

2. *Factory Expense Distribution by Wages*

EXAMPLE

Another, observing this same statement of total costs as given above for the example of factory expense distribution by value of materials, notes that, for every dollar paid to direct labor, a factory expense of $1.00 is incurred. Accordingly, he would estimate the unit cost of manufacture of Product A as unit materials cost $3.00, unit labor cost $2.00, and unit factory expense $2.00, giving a unit cost of manufacture of $7.00. Product B would be estimated to have a unit materials cost of $1.00, a unit labor cost of $2.00, a unit factory expense of $2.00, and a unit cost of manufacture of $5.00.

Now which is the more nearly correct? Each method accounts for the total factory expense for the month, just as we find that 2 + 3 + 5 =10, and 1 + 2 + 7 = 10. But, if the first manufacturer sells each unit of Product A for $9.00, he believes that he has made a unit gross profit of $2.50, whereas the second manufacturer selling each unit of Product A at $9.00 believes that he has made a unit gross profit of $2.00. Which is correct? Maybe both are wrong.

This method of factory expense distribution is based on the theory that each article made incurs a factory expense in direct proportion to the direct labor wage paid in its production. This theory therefore assumes that each item of factory expense is a function of direct labor wages, and, therefore, that the items, for example, of indirect labor—of toolroom service, power and indirect materials, to mention a few—are functions of direct labor wages. Accordingly, let it be assumed that a given plant has in it a group of machines using special tools which must be fitted to the machines for each job, as well as having a group of benches at which skilled mechanics are at work at hand processes. The machine laborers require power for operating the machines, toolroom service for making, repairing, and setting up special tools, laborers to bring casting and take finished parts away, men to repair belts and oil the machinery, men to sweep away the chips. The machinist at the bench requires no such service. He is working with equipment which has little depreciation and makes no demand for power. Is it reasonable to assume that an hour's work at the machines at one dollar per hour will incur a factory expense of only two-thirds of that incurred by an

hour's work by a machinist at the bench who is receiving \$1.50 per hour? Yet that is the basis on which the apportionment would be made by this method. Clearly, therefore, if such conditions obtain in a factory, the percentage on wages method of factory expense distribution is not equitable.

The writers encountered this method of factory expense distribution in a factory manufacturing metal furniture, metal shelving, vault fixtures, bank fixtures, and similar equipment. It served quite well for the apportionment of the factory expense as a whole, that is, there was little over- or under-absorbed expense month by month. It happened, however, that all products did not equally engage the attention of all departments of production. In fact, some products never passed through departments employing very expensive machinery requiring considerable power while other products were largely made at the bench. It was quite evident that the ratio of factory expense to direct labor wages was not the same for all departments. After investigation, it was found that some departments had a ratio as high as 225 percent while in other departments (bench work) the ratio was only 35 percent. The factory as a whole had a ratio of 100 percent. Quite obviously the result of applying the 100 percent ratio to each department was that the cost of some products was estimated too low, and bids based upon these estimates resulted in securing orders on which no profit was being made, while other products were estimated at too high cost and business was not as readily secured in competition with other manufacturers quoting lower prices. Now the plant as a whole was earning a profit, but it was found that, upon reapportionment of factory expense and consequent revision of price lists, the business expanded along safer lines, and larger profits were earned. The fact that one line of products may bring a profit of \$100,000 while another line may lose \$20,000 is not always apparent when the mind is focused on a net profit of \$80,000, especially if that is a fairly good profit on the amount of goods sold.

PRINCIPLES

The conditions under which the percentage on wages method may be fairly applied in the determination of factory costs are:

1. When the skill of the workers and their rates of pay are uniform and the type of equipment they use is fairly similar, and they are all working on the same general class of work.

2. When the factory is divided, for purposes of cost finding, into productive divisions and each division has a proportionate factory expense applied to it in accordance with the extent to which each is responsible for the factory expense, and each division is uniform in equipment, and workers on each product engage the attention of all groups of machines in that division.

If the conditions are as given under (2), it may be found that there are three principal divisions to be known as Department A, Department B, and Department C, and the percentage on wages applicable

to each may be 100, 50, and 125, respectively. A given article may be made in Departments A and C at direct labor costs of \$4.00 and \$3.00, respectively. The factory expense to be charged will accordingly be \$4.00 · 100% + \$3.00 · 125% = \$7.75. Another article may be made in Departments A, B, and C, at direct labor costs of \$2.00, \$5.00, and \$1.00, respectively The factory expense on this article would be \$2.00 · 100% + \$5.00 · 50% + \$1.00 · 125% = \$5.75.

3. Factory Expense Distribution by Direct-Labor-Hours or Man-Hours

EXAMPLE

Upon further examination of the accounts, in the case of the first example, it is found that there were 15,000 direct-labor-hours employed on all the products sold during the month. Accordingly, it may be assumed that on the average for every hour of direct labor accounted for during the month there was incurred a factory expense of 66 2/3¢. While labor received an average of 66 2/3¢ per hour, the rates varied from 40¢ to 90¢ per hour. Let it be assumed that each unit of Product A required 4 hours of direct labor at 50¢ per hour wage. Then, accordingly, the average cost of manufacture of each unit of Product A would be estimated to be: material, \$3.00; labor, \$2.00, as before; and factory expense of 4 · 66 2/3¢ = \$2.66 2/3, totaling \$7.66 2/3. If each unit of Product B requires 4 hours of direct labor at 50¢ per hour, then the factory cost of Product B is estimated to be: material, \$1.00; labor, \$2.00; factory expense, \$2.66 2/3; giving a unit cost of manufacture of \$5.66 2/3.

4. Comparison of the Three Methods

Thus, we find so far three different assumptions by which factory expense may be assessed to the cost of manufacturing the same product, and each assumption leads to a different answer as to what is the unit cost of manufacture of a given article. Each method gives a perfectly satisfactory accounting for the total factory expenses as far as an authentic balance of accounts is concerned. Apparently the problem is more than one of arithmetic.

In general, the man-hour method of expense distribution may be considered more rational than the percentage on wages method, because it is based on the principal factor of factory expense, which is time. However, it must be used with the same discretion and common sense as was indicated for the other methods of expense distribution presented above. Obviously, if the productive departments of a factory vary widely in the nature of equipment and skill of operators, no

average expense per productive hour will be indicative of the real factory expense of any department, and, therefore, not useful in cost determination.

EXAMPLE

The direct-labor-hours per month of the factory for which the analysis of factory expense is given on Table XLII, page 269, were as follows:

Direct-labor-hours	Productive Department				
Total	1	2	3	4	5
30,000	10,000	8,000	6,000	3,000	3,000

Accordingly, therefore, the factory expense is to be apportioned to each product in accordance with the direct-labor-hours spent on it by each department at the following rates:

Department 1 $\dfrac{8{,}700}{10{,}000} = 87¢$ per hour

Department 2 $\dfrac{8{,}690}{8{,}000} = 108.6¢$ per hour

Department 3 $\dfrac{8{,}300}{6{,}000} = 138.33¢$ per hour

Department 4 $\dfrac{7{,}350}{3{,}000} = 245¢$ per hour

Department 5 $\dfrac{4{,}190}{3{,}000} = 139.66¢$ per hour

The average hourly rate will be $\dfrac{37{,}230}{30{,}000} = 124.1¢$ per hour.

Suppose, for example, that a product had been manufactured exclusively in Department 1, and that 10 direct-labor-hours had been spent thereon. If an apportionment of factory expense by departments is made, the product will be charged with a factory expense of $8.70. If, however, the total factory expense is used and all products are assessed at the average hourly rate, then this particular product would be charged with $12.41 factory expense. A product priced on this basis may not be sold in competition with other manufacturers who have a better knowledge of costs. If, on the other hand, a product is made exclusively in Department 4 and consumes 10 direct-labor-hours, it should be charged with a factory expense of $24.50; but if the average rate for the entire plant is used, the factory expense incurred would be estimated at $12.41. Pricing on this basis may result in business being secured, but it would not be profitable.

IV. THE ALLOCATION OF SELLING AND ADMINISTRATIVE EXPENSE—ITS LIMITATIONS

1. GENERAL CONSIDERATIONS

In those industries in which the products made are sold by weight or by some standard unit, for example, pulp mills, sugar mills, brick plants, lumber mills, to mention a few, the total of all expenses including selling and administrative expenses can be divided by the total units of products produced such as the ton, the barrel, the 1,000 board feet, etc., and the total cost of the unit of product obtained. By this means the net profit per pound may be determined. But when a company produces a variety of products or a number of sizes and styles of the same type of product such as table model radios and cabinet model radios with phonograph, the allocation of selling expense and administrative expense to specific products is not permissible by the same rational means as are possible in the allocation of the factory expense. Yet if the profit from the sale of each product is to be found, or more especially if the businessman is to be assured that some products are not being sold at a loss, some basis for the allocation of selling expense and administrative expense must be found. This is particularly necessary in those cases in which some products require much more sales promotion than others or some departments of the business concerned with one or more products demand a disproportionate amount of attention from some of the administrative officers. These conditions are usually found where a new line of products is being promoted by a company and the overhead expenses in development and sales promotion are disproportionate to the sales income of the new product for perhaps several years. It would not be equitable to average the overhead of the entire plant so that the older and better established products are made to carry any of the added overhead. The only rational basis for allocation of selling and administrative expenses in situations as above described is to make a study of the time and expenses of sales and administrative executives in relation to the different products dealt with and from this study set up an approximate proportion to be allocated to each group of products. Unless such a procedure is followed, it may readily happen that the pricing of some products may be out of line with competitive offerings or be so priced as to result in the products being handled at a loss. Accounting techniques for

handling such problems are not well developed, since manufacturers generally price their products on the basis of manufacturing cost and attempt to keep the total of selling and administrative expenses well within the gross profit margin so as to realize a satisfactory profit for the business as a whole.

Many large companies, however, do set up separate sales and administrative divisions for each of the varieties of products they handle, with the result that the major portions of selling and administrative expenses can be properly allocated. But the smaller and medium-sized businesses generally do not departmentalize their overhead activities, and consequently the final or ultimate cost of their products as delivered to the customer may be determined with a high probable error in some cases.

2. CONTROL OF DISTRIBUTION COST ON A GEOGRAPHICAL BASIS

In many instances it will be possible to individualize the selling costs on a geographical basis. This offers the advantage of defining clearly the responsibility of the executive in charge of a given selling district. At the same time, it provides a yardstick of comparison. By comparing the selling expense in one district to the expense in another district, or rather, to the average of the other districts, it is possible to measure, within reasonable limits of approximation, sales executives' efficiency. Of course, such expenses have to be prorated (by dollar of sales, by size of the market, etc.) and some adjustments (for regional variations in disposable income or in the cost of living, for instance), have to be made. The necessity of making some empiric adjustments obviously reduces the degree of accuracy and therefore the reliability of the comparisons made. However, useful estimates of the *relative* efficiencies of sales executives can and should be made.*

3. CONTROL OF DISTRIBUTION COST ON THE BASIS OF THE SIZE OF ORDERS

One of the latest developments in the control of distribution costs is the control on the basis of the size of orders. Except for the conventional classification of wholesale and retail orders, little attention has for a long time been paid to the cost of delivering comparatively small orders. The constant increase in distribution costs is probably the

* See Chapter VII, page 157, for an example of an analysis of cost on a geographical basis.

reason for the extensive studies now being made in the field, notably by the United States Department of Commerce.*

For instance, a detailed analysis of costs showed one company that 42 percent of its accounts, consisting of only 10 percent of the sales volume, were unprofitable. These customers were dropped gradually, whereby marketing expenses were cut from 22.8 percent of sales to 11.5 percent. A 2.9 percent net *loss* on sales was changed to a net *profit* of 15 percent.

4. CONCLUSION

The principal limitations in the allocation of selling expenses come from the lack of detailed data.

The technique of cost accounting has been extensively developed during the last few decades, facilitating a precise analysis of production costs, thereby opening the way for reducing them substantially.

However, the accounting of selling expense did not develop as far as that of production expense. As there is no refined expense allocation directly providing detailed data, empirical studies of costs on a statistical basis have been made during the last few years by Professor Joel Dean of Columbia University, who pioneered the field.† Such studies have thrown light on an important and, up to then, too little known matter, and it is to be hoped that they be continued.

* "How Manufacturers Reduce Their Distribution Costs," Economic Series No. 72, Washington 25, D.C., 1948.

† Joel Dean, "Statistical Determination of Cost," 1936. "The Relation of Cost to Output for a Leather Belt Shop," 1941. "Statistical Cost Functions for a Hosiery Mill," 1941. "The Long-Run Behavior of Cost in a Chain of Shoe Stores," Chicago, 1942. Etc.

XII

COSTS PER UNIT OF OUTPUT

THE SUBJECT MATTER of Part I dealt principally with the economic characteristics of industrial production as applied to a factory and a business as a whole. The preceding two chapters of Part II dealt with some more detailed aspects of the problems of the classification and allocation of the several factors of costs within the factory and the business as a whole. It is our purpose now to consider the problems associated with the determination of the costs of operating a process, and of performing a unit operation, and the relation of such costs to the rate of production. This problem assumes importance when alternate equipments and methods of manufacture are under review. Since a process may be operated or a unit operation may be performed by a number of different methods or by the use of several types of equipment, each one of which is acceptable *functionally*, that is, each one can do the work satisfactorily so far as quality of performance is required, it becomes necessary for purposes of economy to select among the several func-

tionally capable machines and processes that one which will perform the work at minimum cost. But since cost is related to the rate of production, the analysis of the relative costs of unit operations must also take into consideration the quantities to be produced within a given time period. In this chapter consideration will be given to the analysis of costs per unit of output at varying rates of production. The chapter following this one will be devoted to some applications of the analysis to the determination of comparative costs.

1. TYPES OF UNIT COSTS

The term "unit cost" is applied to a number of kinds of units, and therefore it must be amplified to give it specific meaning. The types of unit costs which are of use for control purposes are the following:

a. The *specific* cost of a process or unit of operation and of the units of output resulting therefrom.

b. The *average* costs of *identical* piece parts, such as frames, gears, shafts, etc.

c. The *average* cost of the units of a class of *identical* commercial products such as radios, desks, drills, cloth, etc.

In addition, such unit costs as the expense incurred per dollar of income of the business as a whole or of any division thereof are frequently found helpful in visualizing the economic characteristics of business operations. We will now proceed to investigate the method by which the types of unit costs listed above may be determined, *particularly as they are affected by the rate of production.*

2. AVERAGE COSTS OF IDENTICAL COMMERCIAL UNITS OF PRODUCT

A simple example of identical commercial units of product is a given weight of sugar—the pound. How much does it cost to produce a pound of sugar when the mill is operated at full capacity or 75 percent capacity or half-capacity? The beet sugar mill reported on in Chapter VI was found to have a total expense trend in relation to tons of beets sliced, determined as follows: *

The constant total expenses per annum of the company are estimated to be $1,220,000. The variable total expenses per annum of the company, for capacity operations of 200,000 tons of beets sliced per

* See Chapter VI, pages 136–139.

season, are estimated to be \$1,500,250. The constant unit cost per ton of beets, arising from the variable total expenses is $\frac{\$1{,}500{,}250}{200{,}000} = \$7.50$ per ton. With a yield of 232 pounds of sugar per ton of beets sliced, the constant unit cost per pound of sugar arising from the variable total expenses is:

$$\frac{750}{232} = 3.234¢ \text{ per pound}$$

The constant total expenses of \$1,220,000 give rise to a variable unit cost per pound of sugar of

$$\frac{\$1{,}220{,}000}{232 \cdot T} = \$5{,}215.5 \cdot \frac{1}{T}$$

where T = number of tons sliced per season.
From the above observations, the table of cost per pound of sugar at varying rates of production is prepared (Table XLIII).

TABLE XLIII

TOTAL COST PER POUND

Annual Slice 1000 Tons	Constant Unit Cost	Variable Unit Cost	Total Cost
40	3.23¢	13.03	16.26
60	3.23¢	8.69	11.92
80	3.23¢	6.52	9.75
100	3.23¢	5.21	8.44
120	3.23¢	4.35	7.58
140	3.23¢	3.72	7.00
160	3.23¢	3.26	6.49
180	3.23¢	2.82	6.05
200	3.23¢	2.60	5.83

These items of cost when plotted as in Figure 59 show how each and the total cost per pound vary with the rate of annual production. If the revenue from the sale of pulp and molasses (\$325,600) is credited to operations, the total cost per pound will be reduced for all rates of production by

$$\frac{\$325{,}600}{232 \cdot 200{,}000} = 0.7¢ \text{ per pound}$$

In the above example, there is found a unit of output which is uniform; that is, a pound of sugar is a pound of sugar. If now a similar analysis is made of the cost per ton of steel, for example, as produced by the United Steel Corporation, the average cost so obtained would be the average for rails, sheets, bars, tool steel, and other shapes and qualities. For the 10-year period just prior to World War II, the United Steel Corporation produced steel at an average cost of \$182,-100,000 + \$55.73 per ton. When it produced 14 million tons, as it did in 1928, the average cost was

$$\frac{\$182{,}100{,}000}{14{,}000{,}000} + \$55.73 = \$68.73 \text{ per ton}$$

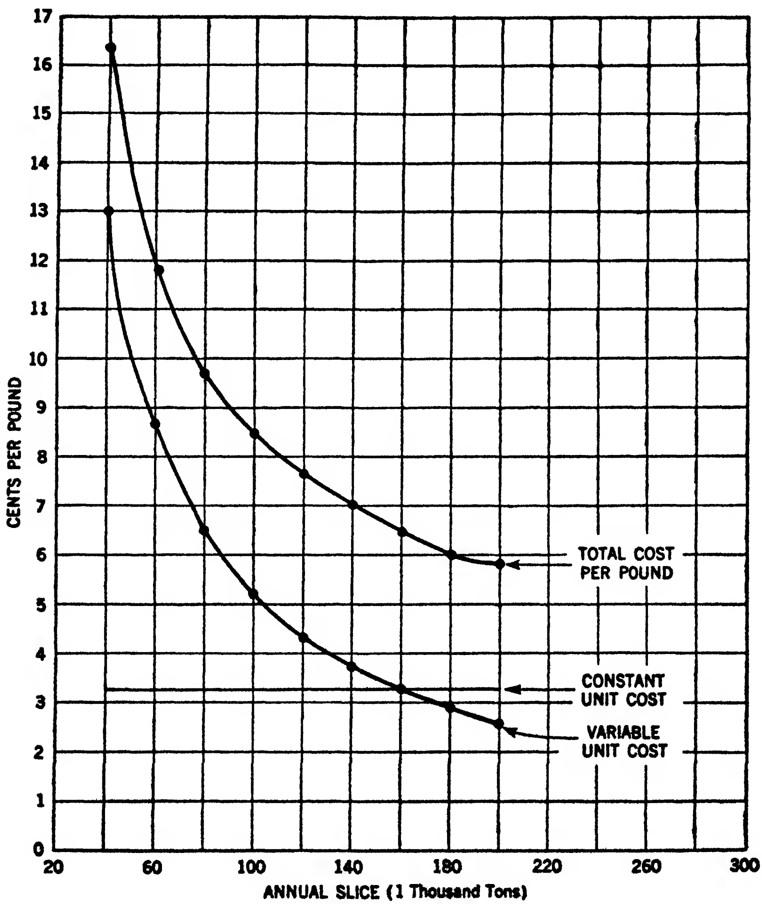

Figure 59. Cost per Pound of Sugar vs. Annual Slice of Beets

In 1938, when it produced 7.8 million tons, the average cost was

$$\frac{\$182{,}100{,}000}{7{,}800{,}000} + \$55.73 = \$79.07 \text{ per ton.}$$

But the different qualities of steel produced were processed by different methods and, accordingly, their costs varied quite widely from the average. In this case, the average costs cannot be used as a basis for pricing the different qualities and shapes. Each quality and shape of steel must be analyzed for cost, if effective control of such costs is to be effected.

In order to ascertain the cost of a product at varying rates of production, particularly a product which is one of several being manufactured in the same plant, but each of which is operated on by different machines, or a product which is assembled from a great number of piece parts, the cost of each unit operation, and of each part as these are operated and produced at varying rates of production, must be found.

3. DEFINITIONS

Unit Operations. The connecting rod of an automobile engine, as manufactured by one company, is machined at 16 stations or work places. The operations performed in sequence are:

1. Grind flash from wrist-pin end
2. Straighten and check location of bosses with face
3. Drill wrist-pin hole
4. Chamfer both sides of rod
5. Broach wrist-pin hole
6. Broach sides of bolt bosses and bolt head seat
7. Drill 3/16″ anchor hole in rods
8. Broach joint face and crank, bore diameter of rod
9. Drill and ream bolt holes
10. Repair bolt holes where necessary
11. Countersink bolt holes opposite joint face in rods
12. Drill 3/16″ angle oil hole, ⅛″ deep and 1/16″ hole through
13. Repair anchor holes and oil holes
14. Burr oil holes
15. Grind joint faces of rod and cap
16. Wash (hot) before assembly.

Each one of these is a unit operation and is performed by a different workman, using particular machines or tools which are adapted to

the job to be done. Each unit operation must be supported by a number of services of maintenance and supply. Each unit operation is conducted at different costs per hour and occasions different costs per piece.

The costs of performing a unit operation arise from three sources, which are:

1. Those due to the possession of the machine
2. Those due to the supporting services
3. Those due to operating the machine.

Each of these sources of cost may be formulated as follows:

The Cost to Possess

The machine or equipment used to perform a unit operation represents an investment. As such it incurs taxes, and it should also be covered by insurance. During the life of the machine, arrangements must also be made for charging an increment of its investment to the cost of the product in order to provide for capital recovery. This is done by the depreciation charge. If, for example, a particular machine represents an investment of $10,000, and it is determined that this capital is to be recovered in 5 years, the annual depreciation charge to the products made by its use will be 20 percent of the investment or $2,000. If the machine is expected to be operated 2,000 hours in the year, then the hourly depreciation charge is $1.00. The tax assessor of the local community in which the factory is located does not assess a tax on each individual machine of the factory but he does assign an assessed value for taxing purposes on the factory as a whole. This assessed value times the tax rate becomes the annual tax which the owners of the business must pay to the community. To reflect this expense in the cost of production, and also that each productive asset may carry its share of the tax burden, it is necessary for the accountants of the business to allocate the taxes to each production division of the factory, and from thence to each unit of production. For purposes of estimating the probable increment of the tax burden to be borne by the production machine the tax rate is applied to the investment in the machine. If the tax rate is 3 percent, the annual tax burden is $300, and for 2,000 hours of operation per year the hourly tax burden is 15¢. The same procedure is applicable to the determination of the insurance burden to be assessed to the machine. If the insurance rate is 2 percent, the annual insurance charge in the above case is $200 and the hourly charge is 10¢.

Accordingly, let

$I =$ the investment in the machine, in dollars
$p =$ the sum of the percentages for annual taxes and insurance and for capital recovery through depreciation
and $N =$ the estimated number of hours the machine is to be in operation during the year.

Then the hourly cost to possess is

$$\frac{I \cdot p}{N}$$

In the above example, if the machine is estimated to be in operation for 2,000 hours in the year, then

$$\frac{I \cdot p}{N} = \frac{\$10{,}000\ (20 + 3 + 2)\ \%}{2{,}000}$$
$$= \$1.25$$

The Cost of Services

Every productive machine must carry its share of the total factory departmental expense.* What this share is to be, in addition to the cost to possess determined as indicated above, is usually estimated by applying an average hourly rate. For example, if the annual departmental expense (not including the specific items accounted for in the cost to possess) is $20,000 per year and there are 20 productive machines in the department which are about alike, then an approximate estimate of the annual cost of service of each machine is $1,000. If the department is operated for 2,000 hours in the year, then the service burden on each machine will be 50¢ per hour. Let the annual service charge be designated by the letter S. Then the hourly service charge is $\frac{S}{N}$.

The Hourly Burden

The cost to possess plus the cost of service expressed in terms of hourly costs constitutes the hourly burden on the machine. In the

* Departmental expense consists of two parts: (1) those directly incurred by the department, and (2) a portion of the total expenses of the service departments.

above example, this is \$1.25 + 0.50 = \$1.75. In symbols, the hourly burden is

$$B = \frac{I \cdot p + S}{N}$$

The Cost to Operate

This item of cost refers to the wages paid to the workman who operates the machine. If the machine must be set up by a skilled mechanic who receives a higher rate of pay than the machine operator, the wages of the set-up man are usually included in the service burden. If the operator of the machine requires a helper in constant attendance, as is the case with certain large machines in which large and cumbersome sheets are cut, punched, or bent, then the cost to operate consists of the wages of the operator plus the wages of the helper. The hourly labor cost of operating a machine may be expressed by the letter L.

In summary, then, the hourly cost to possess, service, and operate a productive machine is

$$\frac{I \cdot p + S}{N} + L \text{ or } B + L$$

4. THE NATURE OF THE COST ITEMS

In order to associate these cost items with the products made, that is, to find the cost per piece, it is necessary to examine the nature of each cost item.

The annual cost to possess, as the term implies, arises solely from the possession of the machine, and is not affected by its operation. If the machine is idle, the *annual* charge is the same as when the machine is operating and producing. But the hourly cost to possess is based on the annual cost to possess and the estimated hours of annual operation. If the machine is estimated to operate full shop time, say 2,000 hours per year, or to be in operation only 1,000 hours and idle 1,000 hours, the hourly cost to possess to be charged to the products made will be twice as much in the latter circumstance as in the former.

The annual cost of servicing the machine consists of two classes, the standard charges and the specific charges. The standard charges of factory expense are such as: cost of maintaining a superintendent, a foreman, storeroom service, materials handling service, accounting service, light, heat, etc. These may be termed stand-by services be-

cause they must be maintained for the department as a whole, ready to render service as needed. These services are rendered to the machine when it is in operation but they must be maintained ready for service even though the particular machine under consideration is temporarily idle.

The specific service charges are those which are incurred when the machine is producing. If the machine is a heating furnace, the specific charges are fuel and relining costs. If it is a lathe, the specific charges are for power to operate and for cutting tools and repairs.

As a rule it is found impractical in most factories to separate these two charges in the accounting for factory expense, and hence they are grouped together as one charge. Since the stand-by charge is usually the dominant one of the two, the annual cost of servicing is treated as a constant cost to be charged to the machine on an hourly basis, whether or no the machine is in operation. For example, if a given department of manufacture has an annual factory expense, not including the cost to possess items, of $20,000 and there are 20 machines in the department, each machine carries an annual burden of $1,000, which must be recovered in the sale of the products which each machine turns out. If the estimated hours of annual operation of the machine are 2,000, the hourly service charge is half what it is if the machine is estimated to operate only 1,000 hours per year.

Cost accounting practices vary over a wide range and the reader should therefore not be surprised to find that the hourly burden on a machine, due to both the cost to possess and the cost of services, is estimated quite differently in many factories. In fact, the writers have observed some very large and reputable companies using such crude and empiric methods for determining machine burdens, with the result that they have been grossly misled as to the costs incurred per unit of output. This has affected seriously the pricing of the product as well as given a false perspective in judging the relative economies of alternate methods of production.

The *cost to operate* is a cost incurred by the wages paid to the operator of the machine plus the wages of the helper, if he has one. It is conveniently computed on an hourly basis. A machine does not need to be turning over to be in operation. If a workman stands by while a machine is being set up, or repaired, it is considered to be in operation. If there is no work to be done by the machine, and the workman is assigned to another job, the machine during that period is not in operation, and there is no cost of operation (labor cost) charged against it. If the machine is operating at a high rate of

production or at a low rate, so long as an operator is in attendance, it bears a constant hourly charge of operation. The operation cost per piece, however, will vary inversely with the hourly rate of production.

5. THE COST PER UNIT OF OUTPUT RESULTING FROM A SPECIFIC OPERATION

The hourly burden to possess and service a productive machine as formulated above is

$$\text{Hourly burden} = \frac{I \cdot p + S}{N} = B$$

The accuracy with which the hourly burden is estimated depends not only on the accuracy with which the factors I, p and S are determined but also the accuracy of the estimate of the number of hours per year (N) during which the machine is expected to operate. In the majority of cases, N = the number of hours the department or the factory operates during the year. If a 40-hour week is observed, N is approximately 2,000 hours. However, if the factory is operated by two 8-hour shifts, it is in operation for 4,000 hours per year. If R represents the rate of hourly production, that is, the number of units or parts operated on by the machine in the hour, then the hourly burden charge per unit of output becomes

$$\frac{I \cdot p + S}{N \cdot R} = \frac{B}{R}$$

In the above example, in which

$$\begin{aligned} I &= \$10{,}000 \\ p &= 25\% \\ S &= \$1{,}000 \\ N &= 2{,}000 \text{ hours} \end{aligned}$$

the hourly burden is

$$\$1.75$$

If the rate of hourly product R varies from 20 to 70, the hourly burden charge per unit of output varies from 8.75¢ to 2.5¢. The hourly burden charge for the entire range of rates of hourly production is shown in Figure 60 by the curve A-B.

The hourly cost to operate is the hourly labor cost L. If, in the above example, L = \$1.25, then as the rate of production varies from 20 to 70 per hour the labor content of the cost per unit of output varies from 6.25¢ to 1.8¢. The labor content of the cost per piece for the entire range of rates of hourly production is shown in Figure 60

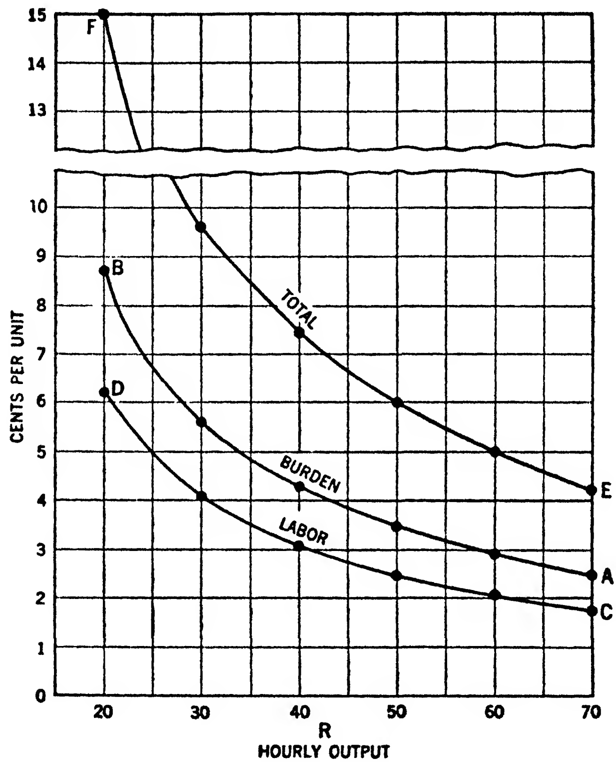

Figure 60. General Pattern of Cost of Labor, Burden and Total Cost, per Unit of Output, at Different Rates of Production of a Machine Where Labor Is in Constant Attendance

by the curve C-D. The total cost per unit of output for the entire range of rates of production is shown in Figure 60 by the curve E-F. In this example, which is typical of many machine shops, it is found that the hourly burden charge is larger than the labor charge and indicates the importance, in cost finding, of the careful estimate of the hourly burden on the machine.

6. THE COST PER UNIT OF OUTPUT AS AFFECTED BY THE CONDITIONS OF OPERATIONS

The condition under which a machine operates or is used in the factory must be taken into account in estimating the cost per unit of output by its use. Among these conditions are the following:

a. The machine is operated for N hours per year but at varying rates of output per hour, according to how it is loaded. For example, a molding press in which a maximum of 10 molds may be accommodated is operated with from 2 to 10 molds, according to its production schedule. The costs per piece of its output vary as shown in Figure 60. Or the machine is a universal machine tool such as a drill press, which, when operating on a given part, can produce 60 per hour, and operating on another part can produce only 20 per hour. The labor cost, the burden, and the total cost for each such part may be found by such a chart as shown in Figure 60.

b. A special purpose machine, adapted to, say, internal grinding of a particular part of a product such as the socket of a transit, when operated is run at full capacity or at maximum rate of production. But as the demand for the product varies, the hours of use of the machine will vary. When the machine is not in operation, the workman who operates it is assigned to work at another job. In such a case, assume that the machine costs \$10,500 and the workman receives \$1.50 per hour, and that the number of pieces produced per hour is 3. Also, it is estimated that $p = 20\%$.

As the demand on the machine varies from 10 to 40 hours per week, or at from 500 to 2,000 hours annually, the burden charge per hour will vary from

$$\frac{\$10{,}500 \cdot 0.20}{500} = \$4.20$$

to

$$\frac{\$10{,}500 \cdot 0.20}{2{,}000} = \$1.05$$

Since the machine produces 3 units per hour, the burden charge per piece varies from \$1.40 to \$0.35.

The labor charge per piece, however, is constant for all demands of use of the machine and is $\$1.50 \div 3 = 50¢$.

The total cost per piece, as well as the labor and burden charges, will vary with the hours per week demand on the machine for the above conditions of operation as shown in Figure 61.

The cost of performing a unit operation on a piece part can be conveniently symbolized by the letter c. In summary, the cost of per-

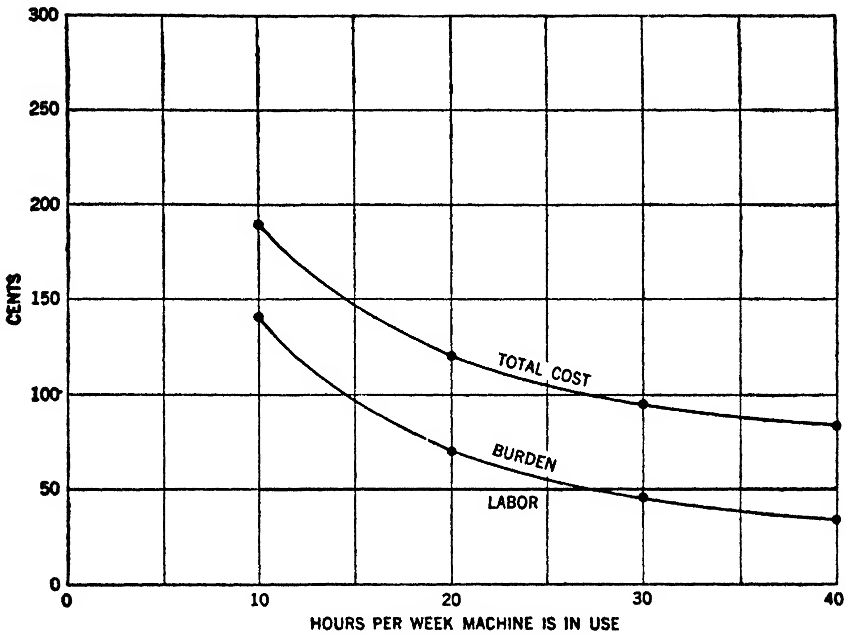

Figure 61. General Pattern of Costs per Unit of Output of a Machine Which Is Always Run at a Fixed Rate but for a Different Number of Hours per Week

forming a given operation by the use of a given machine may be symbolized as

$$c = \text{cost per piece} = \frac{I \cdot p + S}{NR} + \frac{L}{R}$$

7. THE COST OF A FINISHED PIECE PART

The cost of a finished piece part is the sum of the costs resulting from each unit operation performed upon it plus the cost of the material from which the part is made.

Let

m = material cost of the piece part

$\Sigma\,(c)$ = the sum of the costs of each unit operation performed on the piece part

and

f = the cost of the finished piece part

Then

$$f = m + \Sigma\,(c)$$

8. THE COST OF A FINISHED MACHINE

The cost of a finished machine is composed of (1) the sum of the costs of the piece parts, and (2) the sum of the costs of the assembly operations per machine.

Let $F = \Sigma\,(f)$, the sum of the costs of the piece parts

$A = \Sigma\,(a)$, the sum of the costs of the assembly operations per machine

M = the cost of the finished machine

Then

$$M = \Sigma\,(f) + \Sigma\,(a)$$
$$= F + A$$

9. APPLICATION OF THEORY OF UNIT COSTS

The worth of the above formulations of cost depends on the accuracy of estimate of the quantities used in the formulas. In estimating materials cost, for example, the amount of waste in the use of the material should be checked periodically. The extent to which the waste may be reclaimed or sold and credited to operations must be reviewed from time to time. It is also important to compare the service costs assessed each month to the cost of the product with the actual service costs incurred by the department. In other words, cost records should be so organized that up-to-date information is always available for use in cost estimating. Too often cost estimating is based on data which are not representative of current operating conditions in the factory, with the result that errors in judgments which are founded on costs frequently occur and wrong decisions are made. Cost cards should be kept up to date. In the process industries, it is usually important to have complete up-to-date data for every machine or piece of equipment used in performing a major process. The cost to possess and the cost to service the machine or equipment expressed in terms of the hourly burden should be carefully and completely estimated and the data kept up to date. Unless this is done, it is not possible to

judge the comparative worth of a new process and new equipment to carry out the process which may be proposed as a means for lowering present costs.

In the mechanical manufacturing industries of the machine shop type, particularly in case the machines in a given department are quite similar so far as the hourly burden charge is concerned, it is sufficient to pool the costs to possess and to service all the machines of the department and to set up an hourly *departmental* burden in terms of the *anticipated* production hours of the department. For example, if the *monthly* burden of the department is estimated to be $10,000 and the department employs 50 men at *productive labor,* who together will put in 8,000 hours per month, then the hourly burden to be absorbed by each job will be $1.25 per hour for each hour of productive labor performed on it.

10. THE PROBLEM OF DUMPING

When a businessman sells his products in another country than his own, at the approximate cost of manufacturing and handling, he is said to be dumping his goods on the foreign market. By so doing he does not disturb the price situation in the home market, unless the goods are reexported and sold at home at less than domestic prices. He also increases his total profits over that which he would have if he did not produce and sell in the foreign market, even though he may sell these goods abroad at prices less than their cost. This situation may be studied by means of a curve of unit costs.

Suppose, for example, that the unit cost curve of a business is as shown in Figure 62. When the business is operating at 60 percent capacity, the cost per unit of product is $8.80. At a selling price of $10 there is a profit of $1.20 per unit. Let us assume that this product may be sold abroad in considerable quantities at $5.50, f.o.b. plant. By selling abroad at this price, the manufacturer finds he can operate his plant at full capacity and that the product now costs $6.00 per unit to manufacture. How can the manufacturer afford to sell the product abroad at $5.50 when it costs $6.00 to produce it?

It is true that there is a loss of 50 cents on all articles sold abroad, and that this loss is encountered on 40 percent of the plant output. On the other hand, if the domestic market takes 60 percent of the plant output (the cost of production has been lowered from $8.80 to $6.00 per unit and therefore the profits on the domestic business will be increased by $2.80 per unit of product on 60 percent of the plant output and a loss of 50 cents per unit on 40 percent of the plant out-

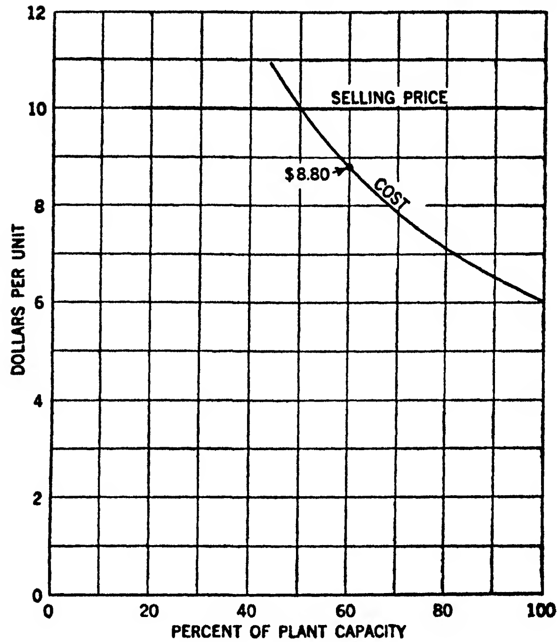

Figure 62. The Unit Cost in Relation to Selling Price

put) the net result is an increase in total profits. The net increase per unit on the domestic business will be

$$\frac{(60 \cdot \$2.80)}{100} - \frac{40 \cdot \$0.50}{100} = \$1.48$$

Whether or not dumping on a foreign market is a good business policy to pursue is another matter.

11. THE ECONOMIC LOT SIZE

a. *The Theory*

The above methods for estimating the cost per unit of output, use the *average* service charges. Among the items of service charge which are averaged are the set-up of the machine for performing a specific operation, the clerical and handling charges incident to putting a lot of parts into production, and the costs of inventory storage. If, in addition to such charges, one considers the working capital requirements of a business and the economic advantage of keeping a minimum investment in inventory for a given annual sales, a new problem arises

in unit costs and that problem is: How does lot size affect unit costs? This problem, of course, arises in shops which put parts in production by batches or lots of parts. In such shops, the practice is to use universal machines adapted to operating on lots of parts by the use of cutters, fixtures, or jigs, which are especially set up for each lot of parts.

In intermittent manufacture a machine of the general purpose type, such as a milling machine, is used to process a sequence of lots of parts. Each process in the sequence is different and requires a special set-up. The cutters and fixtures used on a lot just finished must be removed and new cutters and new fixtures must be installed for the processing of the next lot. The set-up is usually made by a highly skilled mechanic and may take several hours of his time. A less skilled operator, after the set-up is made, is then assigned to the job of processing the lot.

The time required to make a set-up may be two hours. In that case, the cost of the set-up consists of the wages of the skilled mechanic, say two hours at \$1.50 per hour = \$3.00; plus the hourly burden of say \$1.00 for the two hours "down time" = \$2.00. This \$5.00 charge for preparing the machine must be borne by the lot to be processed. If there are 50 pieces in the lot, this will mean 10¢ set-up charge per piece. If only 25 pieces, there will be a set-up charge of 20¢ per piece. If 100 pieces, it will be 5¢ per piece.

The larger the number of pieces in the lot the smaller the set-up charge per piece. If a manufacturer required a given process to be performed on 1,200 pieces in a year, and he processed the whole lot with one set-up of the machine, the set-up cost per piece would be less than if he should process a lot of 100 each month. Processing a lot of 100 each month would require 12 set-ups to process the annual requirements of 1,200 pieces. It would also require 12 times handling of materials (scheduling, routing, and dispatching) and therefore cause additional clerical costs. It is apparent, however, that while the set-up charge per piece is a minimum when the entire annual requirement is processed with one set-up, the ratio of the average annual investment of capital in inventory to annual sales will be a maximum. This means that not only is the earning power of the dormant inventory not being realized, but also there are added expenses incurred in maintaining greater storage capacity.

Accordingly it appears that as the lot size increases, the set-up charges and the clerical costs per piece decline while the idle capital and housing costs increase. At some point in size, the sum of these

costs is a minimum. That point establishes the economic lot size. The determination of this quantity (lot size) apparently depends on the quantitative determination of the costs of set-up, clerical work, idle capital, and housing. If these costs cannot be determined with reasonable accuracy, all we have is a nice theory which cannot be applied. To those who have their costs of operation so organized that the above costs can be determined, the following formulation of the theory of the economic lot size will be of interest:

Let

$N =$ the number of pieces to be produced annually.

$Q = \frac{N}{k}$, the economic lot size where k is 2 or 3 or 4 or 5, etc.

$R =$ the annual cost of housing the average inventory to be carried and the interest charges on the investment in inventory *when the whole annual requirements are produced in one run.*

$r = \frac{R}{k}$

$z =$ the cost of one set-up and dismantling and the cost of clerical and other services incidental to starting a production order.

$Z = zk$

The best value of Q occurs when the sum $Z + r$ is minimum, that is, when the sum $zk + \frac{R}{k}$ is a minimum.

Let this sum be M. Then the best value of Q is had when:

$$\frac{dM}{dk} = 0$$

or

$$z - \frac{R}{k^2} = 0$$

and hence

$$k = \sqrt{\frac{R}{z}}$$

but since $k = \frac{N}{Q}$, then

$$Q = N\frac{1}{\sqrt{\frac{R}{z}}} = N\sqrt{\frac{z}{R}}$$

Example:

Assuming that for a given set-up to process a lot of 50,000 parts, it costs \$25.00 (z) to set up and dismantle the machine and put the lot in production and that the annual cost of housing the average annual inventory to be carried, including the interest on the investment in the inventory, for processing the whole lot (50,000) in one run is \$500, then the economic lot size is

$$Q = 50{,}000\sqrt{\frac{25}{500}}$$

$$= 10{,}000; \text{ the nearest uniform lot quantity.}$$

It must be emphasized again that the accuracy of the estimate of the economic lot size depends wholly on the accuracy of the estimate of the items of cost which enter into the formula. When such cost estimates are attempted, it is frequently found that the accounting system in use is not adequate to estimating the necessary items of cost as the following experience illustrates.

b. *Practical Experience*

The experience of Eli Lilly and Company of Indianapolis, in the determination of economic lot sizes, was reported by Mr. C. H. Best in *The Transactions of the American Society of Mechanical Engineers*, December 1929.* The report is in part as follows:

> For twelve years economic production quantities have governed the sizes of production orders in the plant of Eli Lilly and Company, manufacturers of pharmaceutical and biological products, at Indianapolis, Ind. This paper outlines briefly some of the major results of this practice, both direct and indirect, and discusses some of the cost-accounting problems that were encountered in the derivation of the formulas. The discussion of cost-accounting problems is limited to such problems as might be generally encountered in other plants.
>
> The firm of Eli Lilly and Company manufactures and ships from stock approximately 2,400 products which are marketed in over 8,500 different packages. The problem is to maintain stocks of these 8,500 different items at the lowest possible combined cost of labor of preparation and charges for carrying the merchandise until it is sold.
>
> It was recognized long before 1917 that the quantity produced in a single batch was one of the important factors in determining the cost of producing and carrying the merchandise. Charts and curves were drawn to assist the individual whose judgment determined the batch sizes. These

* While this report is some years old, it contains many references which apply to present industrial conditions.

aids were better than nothing, but they could not even approach the solution of the problem.

In the early part of 1917 work was begun on the assembly of data from which to derive mathematical formulas that would determine the economic production quantity. The task was to express algebraically the total cost of producing a batch of merchandise and of carrying that merchandise until it was sold. This expression has been termed the "total-cost expression," and will be referred to by this term. The first derivative of the total-cost expression, when set equal to zero and solved, gives the economic production quantity or the cheapest batch size that can be made. Larger and smaller batches than the economic production quantity will both produce a higher unit cost than batches made in this exact amount.

During the year 1917 the production of the plant was handled in 25,633 batches with a labor force of 554. Since 1917 the annual output of the plant has very materially increased. In 1928 the increased output was handled in 13,453 batches with a labor force of 482.

A force of about 23 persons carries on the routine detail of the Planning Department, which department has been put into operation since 1917. The Planning Department also operates the perpetual inventory records of finished stock. The work done by the Planning Department is deemed practically indispensable, but the cost of maintaining it would be very substantially more than present costs if production quantities had not greatly reduced the number of operations that have to be planned. Whether this department could function properly at a reasonable cost without economic production quantities is a question.

Automatic materials-handling equipment has reduced trucking to an absolute minimum. This mechanical handling, as well as machine bottling, gang bottling, and machine labeling, has greatly reduced the costs of the various operations that they do. Certainly, to revert to 25,000 batches per year would cause a greatly reduced volume of work that could be handled by this equipment, and consequently reduce the profit from the investment in these devices. It is quite probable that, in many cases, a sufficient return to warrant the investments in these devices could not be estimated if it were not for the reduced number and the consequent increased sizes of the runs that are now made.

During the past five years the inventory of raw materials has been reduced 21½ percent by taking advantage of conditions that were brought about by larger and less frequent batches of staple products. Larger and less frequent batches of staple products suggested scheduling the production of these items in advance, in order that raw-material purchases could be scheduled to arrive just in time to meet the production scheduled. The average inventory of raw materials in 1928 was $185,000 less than it would have been at the same rate of turnover as was experienced in 1923. This $185,000 has virtually been extracted from the business as an indirect result of economic production quantities.

During the year 1917 the finished-stock account was turned three and two-thirds times. During 1928 it was turned four and one-third times. While merely reducing the number of batches to be processed per year

would have gained some of the advantages mentioned in preceding paragraphs, to gain an increase in turnover of finished stock at the same time indicates that regulation of batch quantities has followed the principle of production at minimum cost.

To sum up, economic production quantities have afforded, or have assisted in affording, the following advantages to Eli Lilly and Company:

1. Considerably more production with 13,453 batches in 1928 than with 25,633 batches in 1917.
2. Considerably more production with a labor force of 482 in 1928 than with one of 554 in 1917.
3. Planning-Department supervision of production at reasonable cost.
4. Increase in application of mechanical handling of materials.
5. A reduction of 21½ percent in raw-material inventory.
6. An increase in turnover of finished-stock account from three and two-thirds times per year to four and one-third times.

It would be quite impossible to designate a specific cause as being responsible for any of the six advantages listed above. A progressive management is constantly directing efforts toward the accomplishment of these six, as well as many other objectives, and it is undoubtedly true that the application of the principle of economic production quantities has contributed its share toward making these economies possible.

SOME COST-ACCOUNTING PROBLEMS

It would be very convenient if unit costs of record in the Cost Department could be used directly in the formulas for the determination of economic production quantities. But the cost plan was not designed to furnish unit costs for this particular purpose. Consequently there were numerous adjustments to be made in costs before they could be used.

The cost plan furnishes a unit cost of production for each batch of merchandise processed. This unit cost is broken down into a unit material cost and a unit processing cost. Burden is included in the latter.

The burden includes the cost of all non-productive departments, such costs in productive departments as changes in equipment between runs, and certain preliminary steps in the actual production. It increases the departmental costing rate per machine-hour or per labor-hour.

Following are some of the items of costs which are included in burden, although each item represents a practically constant cost per batch, regardless of the number of units to be produced in the batch.

1. Preparation of complete data on stock and sales to serve as a notice that stocks must be replenished.
2. Blueprinting and registration of the production order.
3. Adjustments to perpetual-inventory records for raw materials to be used.
4. Weighing, checking, and verifying raw materials in the stockroom.
5. Scheduling production by the Planning Department.
6. Checking or assaying the finished product.
7. Calculation of the bottling and finishing orders.

An hour of time spent on the operations listed is just as expensive as an hour of labor in a production department. These costs cannot be carried as overhead charges into an expression of unit cost if this expression is to be diffentiated to determine the batch size that will give a minimum unit-production.

The cost data for use in the formulas for determining economic production quantities were obtained by adjusting the unit labor cost of record. Such elements of this cost of record as are shown above were introduced into the total-cost expression as a series of costs per batch. The unit labor cost of record was reduced to compensate for those component parts of this cost that had been introduced, in some other manner, into the total-cost expression. The remainder of the unit labor cost was then used as the unit cost of the actual production. In this way, as much use as possible was made of the existing record of costs.

For a number of years it was not possible to determine economic production quantities for a line of items made in one large department. The items produced in this department were quite varied in nature. Some were finished in one day, while others took five weeks. The largest equipment in the department would handle 100 times the quantities that the smallest equipment would handle.

The Cost Department could not determine a set of rates that would cost all these products fairly. Several plans were tried out. Records over six or twelve months would be accumulated, then an attempt to use the costs in the formulas would prove the data to be unsuitable for use.

A very detailed study of equipment and costing rates was finally agreed upon as a possible source of a solution. This was carried out and a satisfactory cost plan resulted.

After sufficient cost data were accumulated, the formulas for economic production quantities were derived. Calculations employing the new formulas showed that, with less than $3,500 investment in new equipment, savings could be effected that would more than justify the expenditure. The equipment was ordered promptly and installed. As a result, the batch sizes of 155 items were increased.

Some of the 155 items have not yet been produced since the revision in batch sizes. However, during the first seven months of 1929 the costs in this department, including the overhead charges, represent an annual saving of $11,950. The annual saving will probably reach $15,000 when the full benefit of the change in equipment is realized.

While it took a number of years to work out this problem, which was essentially a problem in accounting, the results have justified the effort.

The experience of Eli Lilly and Company with the application of the principles of economic production quantities indicate that it is just as necessary to study the cost-accounting system as it is to study the problems of the production departments. In fact, the cost-accounting problems have been more difficult of solution than the production problems.

XIII

RELATIVE WORTH OF ALTERNATIVES

EVERY MANUFACTURER when purchasing machinery and equipment is faced with the problem of alternatives. Among a number of machines capable of performing a given class of work he attempts to find the one which has the best economic worth, that is, will perform the required work at the lowest cost.

In the purchase of supplies such as crucibles, hacksaw blades, and oils, the problem of price in relation to serviceability is important. It is not the purchase price which is the sole determining factor. What is being purchased is a capacity to render a specific service and that capacity must be ascertained if one is to make an intelligent choice. This fact is well known in the case of coal. The price per ton of two different types of coal may be the same, but the one which contains the greater heating capacity, minimum ash, and sulphur content constitutes the better purchase since the cost per unit of serviceability is the less. The relative worth of alternative processes of manufacture,

such as the use of jigs and fixtures in place of hand labor, is a problem of daily occurrence in many factories.

What must the rate of production be before it will pay to invest X dollars in jigs and fixtures?

In each of these problems we find that the materials, supplies, machinery, and equipment are used as a means to an end. The end result is a service, and therefore the real questions in each of these cases are: What is the service to be provided and what will it cost?

I. A MACHINE TOOL

Some years ago, one of the writers had occasion to inquire into the relative merits of two lathes for use in rough turning forgings. The problem posed was: Which one had the greater over-all capacity for removing the greater volume of metal in the shorter period of time? This was important to know before comparing prices. Some method for measuring this capacity had to be applied. The method used was that devised by the late J. T. Nicholson and published in his excellent treatise on "Lathe Design." *

The capacity of a lathe for rough turning depends on the speed and the area of cut it can take on all diameters of work it is able to swing. The area of cut in turn will depend on the torque which may be delivered to the spindle. Accordingly, it appears that, if a torque speed diagram is set up for each lathe, their relative capacities for doing rough turning may be judged by a comparison of these diagrams.† Such a comparison is shown in Figure 63 from which it is seen that Lathe A is much superior to Lathe B in capacity to remove metal in roughing operations. The price of each lathe divided by the area of its corresponding speed-torque diagram gave a rational comparison of price per unit of capacity for rough turning.

II. POWER MACHINERY

The relative worths of power machinery of *guaranteed* efficiency and that which is less efficient may be determined as follows.

Certain types of machinery, such as water turbines, steam engines and turbines, electric motors and generators, are usually purchased on guaranteed specifications. Such contracts for purchase formerly provided that the builder was to be compensated for that amount of per-

* Longmans, Green and Co., Ltd., London.

† "A Comparison of Lathe Head-Stock Characteristics," by Walter Rautenstrauch, *Journal A.S.M.E.*, Vol. 32, January-June, 1910.

formance which exceeded the guarantee and likewise a certain amount was to be deducted from the agreed purchase price in case the machinery did not come up to the specified performance. This practice is now discontinued. The question, however, remains: what is the difference in value between the equipment as contracted for at a stated price and the equipment delivered? If a water wheel, for example, is purchased on the basis of 90 percent efficiency, what value should be allowed for each degree of efficiency above 90 percent

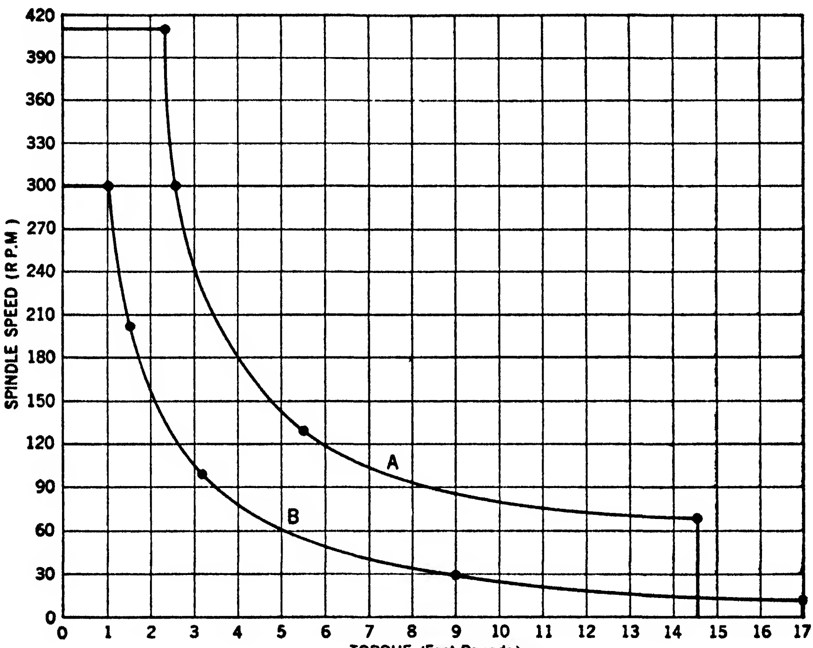

Figure 63. The Speed-torque Characteristics of Two Lathe Headstocks

which may be attained, and, likewise, how much should be deducted from the value for each degree of efficiency less than 90 percent?

To illustrate the principles involved in these situations, let us assume that a machine has been contracted for, which, upon completion, is found to fail in meeting its guaranteed performance. Then it is found that the increase in annual operating cost due to the lower efficiency is $480. If the machine has an expected life of 20 years, the purchaser is put to an additional expense of $480 a year for 20 years, because of the builder's failure to do his work well. Let

us assume—for purposes of illustration only—that in this case the builder, wishing to be fair in the matter and please the buyer, proposes that he will pay this additional annual cost of operation himself, and to guarantee this payment he will place \$8,000 to the purchaser's credit, which, at 6 percent interest (the then current rate), will yield \$480 per year, but at the end of 20 years the purchaser, of course, is to return the \$8,000 to the builder. This is fair enough, but the bad feature about this deal is that 20 years is a long time and many things may happen in the meantime. The purchaser then proposes that, while it is fair for the builder to put up the \$8,000, it would be better not to wait the 20 years for the return of this principal, but, instead, the purchaser will give back to the builder the present worth of \$8,000 for 20 years at 6 percent, which is *

$$P = \frac{A}{(1+R)^N} \text{ or } P = \frac{\$8{,}000}{(1+0.06)^{20}} = \$2{,}496$$

The final result of these two transactions is that the actual value is reduced by \$8,000 — \$2,496 = \$5,504. Accordingly, therefore, the penalty imposed for failure to meet a guarantee is equitably determined by these transactions. The transactions referred to may be summarized as follows:

Let

- $a =$ the annual cost of operation in excess of the guarantee
- $A =$ the principal which at the current rate of interest will yield (a)
- $R =$ the annual rate of interest
- $P =$ the present worth of A after N years at the interest R
- $N =$ the years of estimated life of the equipment
- $L =$ the penalty

Then $$L = A - P$$

But $$A = \frac{a}{R}$$

and $$P = \frac{A}{(1+R)^N}$$

* See Chapter VIII, page 220.

Accordingly
$$L = A - \frac{A}{(1+R)^N}$$

$$= A\left[\frac{(1+R)^N - 1}{(1+R)^N}\right]$$

$$= \frac{a}{R}\left[\frac{(1+R)^N - 1}{(1+R)^N}\right]$$

$$= \frac{a}{R}\left[1 - \frac{1}{(1+R)^N}\right]$$

$$= \frac{aT}{R}, \text{ where } T = \left[1 - \frac{1}{(1+R)^N}\right]$$

T is called the term factor. Values of T are given in Table XLIV.

The question may now be raised concerning the determination of the bonus which should be allowed if the builder exceeds the guarantee. In such event the purchaser is receiving more than he contracted for. Let us assume that because of greater efficiency in operation the purchaser *saves* \$480 per year in operating cost. What is an equitable payment for him to make to the builder? Obviously, the purchaser saves the interest on \$8,000 for 20 years, in consideration of which he proposes to let the builder have the \$8,000 for a period of 20 years, but with the provision that it is to be returned at the end of that time. But instead of waiting the 20 years, the builder proposes to turn back immediately the present worth of the \$8,000. This is exactly what took place in determining the penalty except that the positions of the parties are reversed. Accordingly, either a bonus or a penalty is determined by the same formula.

Example A 500-hp. steam turbine is purchased on a guarantee performance of 14 lb. of steam per hp.-hr. at rated load. The acceptance test shows a steam consumption of 15 lb. per hp.-hr. at rated load. If the cost of steam is 16 cents per 1,000 lb. and the turbine has an estimated life of 20 years, what penalty is to be imposed on the basis of operating 3,000 hours per year, and interest at 6 percent per annum?

TABLE XLIV —— VALUE OF TERM FACTOR, $T - \left[1 - \frac{1}{(1+R)^N}\right]$

(Interest Rate)

Life	3%	4%	5%	6%	7%	8%	9%	10%
1	.029126	.038461	.047619	.05664	.06542	.074074	.08257	.09091
2	.05744	.075444	.092971	.11000	.12656	.14266	.15832	.17355
3	.084852	.11104	.13616	.16038	.18370	.20616	.22781	.24868
4	.11151	.14518	.17729	.20791	.23711	.26497	.29157	.31699
5	.13741	.17811	.21649	.25275	.28702	.31942	.37007	.37908
6	.16248	.20967	.25379	.29511	.33366	.36983	.40375	.43551
7	.18893	.24006	.28932	.33494	.37725	.41651	.45296	.48684
8	.21062	.26933	.32312	.37345	.41798	.45973	.49813	.53350
9	.23360	.29741	.35538	.40810	.45606	.49975	.53957	.57590
10	.25589	.32441	.38609	.44161	.49165	.53679	.57758	.61446
11	.27756	.35039	.41530	.47321	.52488	.56109	.61246	.64951
12	.29868	.37539	.44313	.50303	.55599	.60083	.64446	.68137
13	.31903	.39945	.46966	.52115	.58464	.63299	.67382	.71034
14	.33889	.42254	.49492	.55769	.61608	.65953	.70075	.73667
15	.35816	.44472	.51897	.58275	.63756	.68476	.72542	.76061
16	.37683	.46611	.54186	.60633	.66127	.70812	.74812	.78237
18	.41259	.50636	.58448	.64885	.70414	.74976	.78800	.82014
20	.44632	.54361	.62312	.68821	.74158	.78545	.82157	.85136
25	.52241	.62488	.70469	.76700	.81575	.85396	.88403	.907706
30	.58804	.69167	.76861	.82588	.86864	.90064	.924626	.942691
35	.64461	.74658	.81871	.86990	.90636	.93239	.951021	.964417
40	.69529	.79171	.85795	.90279	.93324	.95397	.968161	.977906
50	.77189	.85298	.91279	.94569	.96696	.97868	.986551	.994818
60	.83016	.90504	.94644	.96971	.98274	.99012	.994319	.9967159
75	.89105	.94770	.97426	.98736	.993745	.99689	.9904403	.9992138
100	.94804	.980198	.992395	.997057	.998500	.99955	.9998191	.9999274
Inf.	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

From Goldman, *Financial Engineering*, Second Edition, page 31, John Wiley & Sons, Inc., New York, 1923.

SOLUTION The excess steam consumption per year is $500 \cdot 3{,}000 = 1{,}500{,}000$ lb., which at 16 cents per 1,000 lb. occasions an increase in operating costs of \$240 per year. Accordingly:

$$\begin{aligned} L &= \text{penalty} \\ a &= \$240.00 \\ R &= 0.06 \\ N &= 20 \text{ years} \\ L &= \frac{240}{0.06} \cdot 0.688 \\ &= \$2{,}752 \end{aligned}$$

If the purchase price agreed on was \$15,000, this will then be reduced to \$12,248 to compensate the purchaser for the increase in cost of operation.

EXAMPLE A 400-kw motor is purchased for \$1,600 to have an efficiency of 93 percent at full load. The motor upon test is found to have an efficiency of only 91 percent. If power costs 2 cents per kwhr and the motor is to run at full load for 3,000 hours per year for the life of the motor, which is estimated at 10 years, what reduction should be made in the purchasing price on the basis of an interest rate of 6 percent per annum?

SOLUTION If the motor is 2 percent less efficient than guaranteed, it will consume $\frac{400}{0.91} = 440$ kw per hour instead of $\frac{400}{0.93} = 430$ kw per hour, or 10 kw per hour more. In 3,000 hours and at 2 cents per kwhr there will be $10 \cdot 3{,}000 \cdot 0.02 = \$600$ additional cost per year for current. Accordingly:

$$\begin{aligned} a &= \$600 \\ R &= 0.06 \\ N &= 10 \text{ years} \\ L &= \frac{600}{0.06} \cdot 0.4416 \\ &= \$4{,}416 \end{aligned}$$

This appears to be a ridiculous figure, for it implies that the purchaser could not accept the motor as a gift unless the maker would also present him with the sum of $\$4{,}416 - \$1{,}600 = \$2{,}816$, which, of course, is out of the question. This problem is given, however, to emphasize the importance of using the proper-sized motor on a given load. Very

frequently a shop will have a collection of motors on hand in the maintenance department and the master mechanic not infrequently will select a 10-hp. motor for a 6-hp. load. Motors always run at low efficiency when operated at fractional capacities, with the result that power costs are higher than they would be if motors rated at load requirements were used.

III. THE DETERMINATION OF THE RELATIVE WORTHS OF SEVERAL COMPETITIVE MACHINES

The relative worths of several machines which are each equally adapted to performing a specific service may be determined by comparing the cost per unit of output of each.

In Chapter XII the factors of cost per unit of output were defined and formulated as follows:

$$c = \text{cost per unit of output}$$
$$= \frac{I \cdot p}{N \cdot R} + \frac{S}{N \cdot R} + \frac{L}{R}$$

where I = the investment in the machine
p = the annual percentage of fixed charges which is the sum of the percentages of the investment representing the annual charges for insurance, taxes and depreciation
N = the number of hours the machine is to be operated during the year
R = the rate of production per hour, that is, the number of units of output the machine is capable of producing in the hour
S = the annual service charges to be borne by the machine during the year
L = the hourly wages of labor engaged in operating the machine

The following examples will illustrate how this formula is used in determining which of several machines capable of doing the same job is to be preferred.

Example 1 **The comparative worth of two machine tools.**

a. *Both machines used continuously throughout the year.* Two Machines, A and B, are available for performing a given operation. They differ in investment, in the rate of production, in the skill of the

operator, and in the cost to maintain (hourly service charge). They compare as follows:

Item	Machine A	Machine B
I = investment	\$4,000	\$6,000
p = annual percentage of fixed charges	7%	20%
L = hourly wage	125¢	110¢
$\frac{S}{N}$ = hourly service charge	90¢	90¢
R = pieces per hour	5	8
N = annual shop hours	2,000	2,000

Accordingly, for Machine A

$$c = \frac{400{,}000 \cdot 0.17}{2{,}000 \cdot 5} + \frac{90}{5} + \frac{125}{5} = 49.8¢$$

For Machine B

$$c = \frac{600{,}000 \cdot 0.20}{2{,}000 \cdot 8} + \frac{90}{8} + \frac{110}{8} = 32.5¢$$

Therefore, Machine B, while higher in first cost (investment), has the greater economic worth since it can produce at a lower cost per piece.

b. *Limited annual production, neither machine available for other purposes.* This situation arises with special purpose machines such as one designed to machine a valve body preparatory to the insertion of the valve seat. If the annual production of valves declines, the machine not adaptable to other purposes is idle.

Assume the above machines are of this character and the annual production of the shop is 10,000 valves per year. In this case, Machine A, with a rate of production of 5 per hour, will be running full time (2,000 hours per year). Machine B, however, will run only 1,250 $\left(\frac{10{,}000}{8}\right)$ hours per year or 62.5% of full shop time.

This will result in increases in the hourly cost to possess per operating hour and the service charge per operating hour. Hence

$$c = \frac{600{,}000 \cdot 0.20}{1{,}250 \cdot 8} + \frac{90}{8 \cdot .625} + \frac{110}{8} = 43.75$$

And so although Machine B is to be idle 37.5 percent of the time, it still is a better buy, and for an annual production of 10,000 pieces per year there will be a saving in cost of \$605 per year.

EXAMPLE 2 The selection of power machinery.

A choice is to be made between a diesel engine plant, a steam plant, and an electric motor using purchased power. The capacity required of each is 1,000 horsepower. The plant is to operate for 3,000 hours during the year. The diesel plant will cost $130,000 and will have an operating cost (labor, service charges, and fuel) of 0.6 cents per hp.-hr. Its estimated life is 15 years.

The steam plant will cost $96,000 and incur an operating cost of 1.2 cents per hp.-hr. It has an estimated life of 20 years. The motor will cost $11,000 and is estimated to have a life of 25 years. It has an efficiency of 92 percent. The cost of current is 2 cents per hp.-hr. The cost of insurance and taxes in each case is 10 percent. The annual rate of depreciation is 6 2/3 percent for the diesel plant, 5 percent for the steam plant, and 4 percent for the motor. Accordingly, the factors determining the cost per hp.-hr. in each case are (Table XLV):

TABLE XLV

COST OF POWER (COMPARATIVE STATEMENT)

Item	Symbol	Amounts		
		Diesel	Steam	Motor
Investment	I	$130,000	$76,000	$11,000
Percentage	p	16 2/3	15	14
Hourly wages and service charges including fuel	$\frac{L+S}{N}$	$6.00	$12.00	$\frac{\$\,20}{.92}$
Hourly production	R	1,000 hp.	1,000 hp.	1,000 hp.
Annual hours of operation	N	3,000	3,000	3,000

For the diesel plant

$$c = \frac{\$130{,}000 \cdot 100 \cdot 0.166}{3{,}000{,}000} + 0.6¢$$

$$= 1.322¢ \text{ per hp.-hr.}$$

For the steam plant

$$c = \frac{\$96{,}000 \cdot 100 \cdot 0.15}{3{,}000{,}000} + 1.2¢$$

$$= 1.68¢ \text{ per hp.-hr.}$$

For the electric motor

$$c = \frac{\$11{,}000 \cdot 100 \cdot 0.14}{3{,}000{,}000} + \left(\frac{2.00}{0.92}¢\right)$$

$$= 2.224¢ \text{ per hp.-hr.}$$

The diesel plant, though higher in investment, is the best choice.

EXAMPLE 3 The selection of processing machinery for the replacement of hand labor.

Assume that it costs $1.00 per cu. yd. to excavate earth by hand labor. A contractor has about 1,000,000 cu. yd. of earth to excavate in a given time. If he employs hand labor he can work each man 2,000 hours during the year. If he uses a machine for excavation, let us assume that he can use it for excavating only 1,500 hours during the year because of having to move the machine from one job to another. An excavating machine which will remove earth at the rate of 40 cu. yd. per hour will probably cost $15,000. Compare the unit costs of machine operation and hand labor.

For the excavating machine we find as follows: One machine working 1,500 hours per year at the rate of 40 cu. yd. per hour will remove 60,000 cu. yd. of earth. Since there are 1,000,000 cu. yd. to be excavated during the year, the contractor will need 17 machines. These machines have a life of 8 years. Depreciation will be assumed at the rate of 12½ percent per year. Taxes and insurance will cost 7½ percent. The cost of fuel, repairs, and operating labor is estimated to be 12¢ per cu. yd. Accordingly:

$$c = \frac{0.20 \cdot 15{,}000 \cdot 100 \cdot 17}{1{,}000{,}000} + 12¢$$

$$= 17.1¢ \text{ per cu. yd.}$$

To excavate by hand labor, it is estimated the cost would be

$$c = \$1.00 \text{ per cu. yd.}$$

Therefore, the total cost of excavating 1,000,000 cu. yd. of earth in one year will be:

By machine:	$ 171,000
By hand:	$1,000,000

It is evident that the machine will more than pay for itself in less than 6 months' time.

EXAMPLE 4 The selection of jigs, fixtures, and tooling equipment. A certain piece of work is done in a machine shop at a labor cost of \$3.75. The mechanic is skilled and receives \$1.25 per hour; it takes him 3 hours to do the work. It is proposed that a fixture or jig be made to facilitate the work. Upon investigation it is found that four jigs will be required and the total cost will be \$1,500. It is also found that a less skilled man can be employed to do the work if the jigs are used and he can be secured for \$1.00 per hour. It is also estimated that the use of the jigs will permit the work to be done in one hour. Considering the item of the jigs above and neglecting consideration of the probable idleness of the drilling machine due to the work being done in one-third of the time, the question is raised: How many pieces will need to be made before the jigs will pay for themselves? This is the same as the question: How many pieces will need to be processed by means of the jigs to result in the cost of processing per unit of product being equal to that without the jigs?

In addition to the above facts, consideration must be given to the following:

1. The depreciation, repairs, insurance, interest, and tax items on the jigs will be 70 percent of their cost annually.
2. The factor (S) service charge will be assumed to be 100 percent on labor under both circumstances.

Accordingly, the cost per unit of output by means of the jigs is determined as follows:

For the use of the jigs

$$I \cdot p = \$1{,}500 \cdot 0.70 = \$1{,}050$$

and

$$\frac{I \cdot p}{n} = \frac{\$1{,}050}{n}$$

also

$$\frac{L + S}{R} = \frac{\$1.00 + \$1.00}{1} = \$2.00$$

Then

$$c = \frac{\$1{,}050}{n} + \$2.00$$

For the use of hand labor

$$c = \frac{\$1.25 + 1.25}{\tfrac{1}{3}} = \$7.50$$

Accordingly, the number of pieces to be produced in one year, above which the investment in the jig is justified, is found by equating the two costs and solving for N.

Thus

$$\frac{\$1,050}{n} + \$2.00 = \$7.50$$

or

$$n = 192 \text{ pieces}$$

IV. THE COMPARATIVE ECONOMIC WORTH OF MATERIALS AND SUPPLIES

A special case in value determination arises in the purchase of materials and supplies. The value of certain materials and supplies used in the processes of manufacture resides in their capacity to render certain given amounts of service. An excellent method for making a rational determination of such values was developed at the Bureau of Engineering of the United States Navy and described by Timothy J. Keleher, Commander, United States Navy, and Frank M. McGeary, Material Engineer, United States Navy, in *Manufacturing Industries* of July, August, and September, 1928.* Their report is as follows:

PURCHASE ON A WORK FACTOR BASIS

Standard Tests for Industrial Supplies Bought by the United States Navy Are Applicable to Items Purchased by Manufacturing Plants

TIMOTHY J. KELEHER, Commander, United States Navy

The phrase "purchase on a work factor basis" is used here to mean purchase on such a basis as will ensure the minimum cost per unit of service.

One way to determine differences in service is to test samples of the articles under consideration in a manner which simulates service conditions. For a person equipped with knowledge based on experience it is practicable to select the most important factors which enter into the service of articles, and in many cases it is possible, without prohibitive expense, to test these articles in a way that will ensure reasonably accurate results.

Specifications as commonly understood must of necessity be statements of minimum acceptable requirements. When competition becomes keen, this tends toward the delivery under contract of material which will be no better than the very lowest quality acceptable under the specifications.

* The principles of this procedure are applicable today.

QUALITY AND SERVICE VARY

Materials of the same kind but of different manufacture will always vary as to quality. Hence, if a way can be developed of determining these differences in quality, which means determining the differences in service to be expected, such development surely is desirable. It would appear reasonable, therefore, to work up specifications which would describe in detail the minimum acceptable requirements, and then to develop around each specification a work factor basis which would give the maximum service for the minimum cost.

At first thought, this may appear to involve a highly scientific investigation, during which cross currents may develop and lead in so many directions that no conclusive results will be possible. Further consideration, however, will show that it is entirely feasible for a consumer to develop, for many kinds of material, work factors based on actual service use of the material.

The problem is to select the variable factors entering into the service of a given material under its usual condition of use, and to reduce these factors to a simple mathematical formula, in conjunction with an easily duplicated test, which shall simulate—in a test laboratory, let us say—actual service conditions.

FRANK M. MCGEARY, Material Engineer, United States Navy

While it might be possible, in time, to evolve a scientifically correct work value for every brand of material, it is not believed that this is necessary or even desirable, since a correction would have to be applied for each consumer, and for each use, to overcome differences in operating conditions. As the one who pays the bills, each consumer should decide what grade of material he desires to purchase, develop a specification as to minimum quality in order to identify the material, and establish work factors of a number of brands of the material, based on the kind of service expected. When the material is to be used for different kinds of service, the work value should be based on the most important service from the operating standpoint.

From a number of such studies, a few examples will be cited to illustrate what has been done along these lines and to point the way to future accomplishments.

HIGH PRESSURE ROD PACKING

In the matter of asbestos high pressure rod packing, comparative tests among 12 brands have shown the following results:

The quantities of packing required for the tests varied from 1.80 to 3.12 pounds.

The friction developed varied from 0.97 to 1.73 hp.

The endurance of packing varied from 371 to 2,056 hrs. It is apparent from these results that there are at least three variables in the cost of rod packing for any stuffing box—weight of material necessary, friction developed, and endurance of the packing.

Examples of actual tests show that, assuming a uniform price of $0.80 per pound of packing, which, under existing circumstances, is a reasonable assumption, 68 percent greater service should be expected from the best packing as compared with the poorest.

METHOD OF TESTING ROD PACKING

The following method has been worked out for determining the work value of asbestos high pressure rod packings. A comparative test of a large number of brands of asbestos high pressure rod packing is now being made.

1. *Endurance Test, Reciprocating Rod.* The apparatus consists of a number of double-ended stuffing boxes mounted on two angle-iron frames, attached on opposite sides to a cast-iron base. A steel rod 2" in diameter connected to a cross-head in each frame is made to reciprocate through the stuffing boxes. The cross-heads in the angle-iron frames receive their motion from crank arms connected 180° apart to a worm and gear on a 10 hp. electric motor.

Each double-ended stuffing box is a cylindrical-shaped casting 10" long, with a steam space in the center and a stuffing box at each end. The steam space of each casting is slightly larger in diameter than the stuffing boxes at each end, which are 3 1/16" in diameter and 3 ¾" deep.

By means of a valve mechanism, which receives its motion from a rocker arm connected to one of the cross-heads of the apparatus, high pressure steam is alternately admitted and discharged to and from the steam space of the stuffing boxes during each stroke of the reciprocating rods. Throughout the test, the rods of the apparatus are operated at a speed of 100 strokes per min. with a stroke of 12".

Two sets of packing are installed for test in the stuffing boxes of the apparatus. One set is installed in a lower or downward-facing stuffing box, and the other is installed in an upper or upward-facing stuffing box. During the test the weight and number of turns of packing initially and additionally installed in each stuffing box, and the gland adjustment necessary to prevent or check steam leakage are recorded. The test is considered complete when leakage cannot be controlled. During the test the apparatus operates 8 hrs. daily, being started cold each day.

2. *Friction Test, Reciprocating Rod.* This apparatus, with the exception of having only one double-ended stuffing box, is similar in operation and construction to the endurance-testing machine. The friction-testing apparatus is equipped with a stroke counter, a voltmeter, and an ammeter, which are used to determine the speed and the power of operation.

Before and after the test of each packing, a zero load or the power required to operate the apparatus is determined. The weight, number of turns of packing installed in each stuffing box, and the gland exposure are recorded before the test of each packing.

The readings of the stroke counter, voltmeter, and ammeter are recorded at the start and hourly thereafter during the test. The gland exposures and the amount of steam leakage are also recorded during

the test. The piston or reciprocating rod operates at a constant speed of 75 strokes per min. and with a stroke of 12". The glands of the stuffing box are adjusted to compress packing so as to prevent or check steam leakages and absorb the least amount of power. Then if the glands are in a position where they cannot be further adjusted and the frictional load is still too high, the apparatus is stopped and a ring of packing is removed from each stuffing box. This test is continued for a period of 48 hrs. or more with not more than 8 hrs. of operation daily, the apparatus being started cold each day.

3. *Friction Test, Rotary Rods.* The apparatus consists chiefly of a double-ended test stuffing box, a rotary steel rod, and a vacuum-obtaining device. The double-ended stuffing box is a cylindrical-shaped casting 10" long, with a steam space in the center and a stuffing-box at either end. The steam space is slightly larger in diameter than the stuffing box at each end. The stuffing boxes are 3¼" in diameter and 3¾" deep. The rotary rod is 2" in diameter and is made of cold rolled steel. It is connected directly to a high-speed electric motor.

Samples of the packing to be tested are installed in each stuffing box of the test apparatus. For a given time during the test, the packing is subjected to working conditions, at steam pressure of 25 lb. gage, to the highest obtainable vacuum, and to steam at a pressure of 150 lb. gage. During the test the rod rotates at a speed of 3,300 rpm and the packing is subjected to 50 hrs. of running under each of the above conditions, as applicable. The glands of the stuffing boxes are adjusted to compress the packing sufficiently to prevent or to check leakage, and at the same time to absorb the least amount of power. Any uncontrollable steam leakage occurring during the test is recorded. During the vacuum run, any air that leaks through the packing into the steam space is drawn off through the vacuum-obtaining device, passed through a meter, and measured.

The speed of the rod, and the power of consumption due to frictional resistance, are determined from hourly readings of the revolution counter, a voltmeter, and an ammeter. In order to determine accurately the power absorbed by the frictional resistance of the packing when subjected to the various conditions of the test, a zero load, or the power required to rotate the rod with no packing in the stuffing boxes, is determined before and after the test of packing.

The temperature and pressure of the steam in the steam space of the stuffing box are obtained from mercury glass thermometers and a calibrated compound gage. The weight and number of turns of packing installed in each stuffing box, and the required gland adjustments, are recorded during the test.

4. *Steam Conditions During Tests.* All high-pressure rod packings are tested under saturated and superheated steam conditions as follows:

a. The endurance test reciprocating rod is run with superheated steam at pressures from 250 to 290 pound gage, and the steam temperature averaging 700° F., with a maximum of 730° F.

b. The friction test reciprocating rod is run with saturated steam at a maximum pressure of 25 pound gage.

c. The rotary rod friction test is run with saturated steam at a maximon pressure of 25 pound gage.

5. *Method for Determining Work Value.* Upon completion of the test, each packing is given a rating, corresponding to its relative work value. This is substantially a cost per hour of service determined by considering the following factors:

a. Total cost of packing required to complete the test (original installation plus additional rings required during the test)
b. Total effective service in hours
c. Average friction (in horsepower) due to packing.

The cost per hour of service is determined by the following formula:

$$W = \frac{(b \cdot c) + (A \cdot d \cdot e)}{A}$$

In which W = work value or cost per hour of service
A = total effective service, in hours
b = total weight of packing required for test in pounds
c = cost of packing per pound
d = average friction in horsepower
e = \$0.01 per hp. per hr. (arbitrary cost of friction)

This formula is applied in Table A to a test of five samples of packing, and the work values shown in the last column are obtained.

In the calculation used to arrive at the work value a price per pound of \$0.80 has been used for all packing. The work value or cost per hour of service ranges from \$0.0113 to \$0.0190, the latter being 68 percent greater than the former.

In Table B the work factor method is applied to purchases where different prices are bid on the brands represented by the samples.

FOUNDRY CRUCIBLES

Foundry crucibles have been found to give erratic service. Manufacturers contend that crucibles are abused in service, while foundrymen claim poor results are due to inferior quality. There is probably some merit in both contentions, although under the system of purchasing crucibles in vogue heretofore, i.e., award of contract to the low bidder for crucibles conforming to the minimum requirements of the specifications, neither contention could be readily disproved. Under the work value method of purchase, it is possible to fix the responsibility for failure. If a manufacturer is found at fault, relief can be obtained in the form of additional crucibles, without cost to the consumer. If the foundrymen are at fault, steps can be taken to improve operating conditions in the foundry in question, and so indirectly to accomplish economies which, although not actually determinable, should be credited to the work factor system of purchase.

In an actual comparative test, it was found that the best set of samples of crucibles gave 103 percent greater service than the next best set,

and that the price of the best crucibles was 41 percent greater than the price of the next best. Comparing the best with the poorest, the service difference was 587 percent and the price difference 82 percent.

TABLE A

WORK VALUE OF ROD PACKING

Sample	Weight of Packing Required	Price per Pound	Total Service, Hours	Friction Developed, Horsepower	Work Value Cost per Hour of Service
A	2.84	$0.80	1,421	0.97	$0.0113
B	1.80	0.80	2,056	1.35	0.0142
C	2.40	0.80	371	1.30	0.0181
D	3.12	0.80	886	1.43	0.0172
E	2.22	0.80	1,128	1.73	0.0190

TABLE B

SERVICE COST OF ROD PACKING

Sample	Weight Required per Pound	Bid Price per Pound	Total Service Hours	Friction Developed	Service Cost per Hour
A	2.84	$0.68	1,421	0.97	$0.0110
B	1.80	0.78	2,056	1.35	0.0141
C	3.12	0.85	886	1.43	0.0173
D	2.22	0.70	1,128	1.73	0.0186
E	2.40	0.92	371	1.30	0.0189

TABLE B

METHOD OF TESTING CRUCIBLES

The following method of obtaining work values has been established for foundry crucibles. Tests for approval of brand are made as follows: Three Number 125 crucibles are used on regular foundry work, with the usual foundry practice, and in a natural-draft coal or coke furnace. To make the tests as uniform as practicable, only copper-tin or copper-zinc-tin alloys containing less than 3 percent lead and 0.05 percent phosphorus are used. All test crucibles are used to destruction, and careful records are kept, showing the number of heats, the number of hours in the fire, the composition of the material melted, from which the working temperature is computed, and the cause of failure. The work value is then determined by the simple formula:

$$\frac{a\ b\ c}{1{,}000}$$

in which a = average number of heats
b = average number of hours in the fire, per heat
c = average working temperature in degrees F

In applying the formula to different sizes of crucibles, it was found that a better work factor was consistently obtained on smaller sizes than on larger sizes. This made it necessary to add a factor to the formula which would reduce all sizes to a common basis. In actual practice, it has been found that the expression

$$\frac{\text{average working temperature in degrees F}}{1{,}000}$$

added to the formula, gave a close check on different sizes of crucibles from the same manufacturing source.

A number of tests have been made on this basis in Table C. Two records are shown to give an idea of the results obtained.

TABLE C

FOUNDRY CRUCIBLE TESTS

ITEM	Crucible 1	Crucible 2	Crucible 3
Sample A			
Average number of heats (a)	76.00	76.00	86.00
Average number hours in fire (b)	2.97	3.47	3.34
Average temperature in degrees F (c)	2,080.00	2,070.00	2,060.00
Sample B			
Average number of heats (a)	43.00	35.00	45.00
Average number hours in fire (b)	3.21	3.21	3.02
Average temperature in degrees F (c)	2,050.00	2,050.00	2,050.00

Results

ITEM	Sample A	Sample B
Crucible 1	$\frac{76 \cdot 2.97 \cdot 2{,}080}{1{,}000} = 467.92$	$\frac{43 \cdot 3.21 \cdot 2{,}050}{1{,}000} = 282.96$
Crucible 2	$\frac{76 \cdot 3.47 \cdot 2{,}070}{1{,}000} = 545.89$	$\frac{35 \cdot 3.21 \cdot 2{,}050}{1{,}000} = 230.31$
Crucible 3	$\frac{86 \cdot 3.34 \cdot 2{,}060}{1{,}000} = 590.85$	$\frac{45 \cdot 3.02 \cdot 2{,}050}{1{,}000} = 278.59$
	Total 1,604.66	Total 791.86
	Work value (average) 534.89	Work value (average) 263.95

From the calculation in Table C, the crucibles represented by Sample A should give 102 percent more service than those represented by Sample B. To check deliveries, samples are taken from each lot of crucibles delivered on contract, and tested in the receiving foundry, by the method described.

When crucible contracts provide for deliveries at a number of foundries belonging to the same organization, the check test will serve two purposes: It will determine whether crucibles of uniform quality are supplied on contract, and it will give a direct comparison of the results obtained at the different foundries.

Applying the work factor to purchases, the results shown in Table D are obtained.

TABLE D

SERVICE COST OF CRUCIBLES

Bid	a Bid Price per Crucible	b Average Number Heats	c Average Number Hours in Fire	d Average Working Temperature Degrees F.	e Work Factor	Service Cost of Crucible per Hour a ÷ e
A	\$10.095	79.3	3.256	2,070	534.89	\$0.0204
B	7.184	41.0	3.146	2,050	263.95	0.0268
C	7.184	21.0	3.300	2,060	142.76	0.0503
D	7.256	22.0	3.070	2,050	138.45	0.0523
E	7.980	20.0	3.220	2,060	132.65	0.0603
F	5.565	11.3	3.400	2,030	77.99	0.0713

Valve-Grinding Compound. On a test made by the Navy Bureau of Engineering on seven samples of valve-grinding compound, "pounds ground away per pound of valve-grinding compound" varied between 0.173 and 0.403. The best compound gave over 2.3 times greater service than the poorest, whereas the price of the best compound was only 1.17 times that of the poorest. The best removed a pound of metal in 17 hrs. while it took 40 hrs. to remove a pound of metal with the poorest compound. The labor costs with the poorest compound would be about 2.3 times as much as when using the best.

The following method has been developed for determining the work value of valve-grinding an engine poppet valve in its seat. The machine consists of three units with a single driving mechanism. The valve seat is simulated by a 2″ diameter, ½″ thick disc of cast iron of 143 Brinell hardness number, which is superimposed on a seat which simulates a valve, being steel of 267 Brinell hardness number. While these valves vary considerably from actual conditions sometimes found, the important thing is to have all compounds tested identically, and these values are maintained throughout each test. The shaft on which the disc is attached is rotated 1¼ revolutions in one direction by a rack operating a pinion, then driven a similar number of revolutions in the opposite direction. Once during each such cycle the disc is lifted completely from its seat by a cam attached to the rack. The machine is driven at a uniform speed of 70 cycles per min. While seated, the discs are pressed together with a pressure of 5 pounds a sq. in. by means of the top weight. Grinding compound is fed to the surface between the discs through a groove on the seat from graduated compression cups turned by hand every 2 min. at such a rate as to give 6.5 grams of compound to the surface every hour.

Each top and bottom disc is cleaned and weighed on chemical balances before and after each 2-hr. test.

A work value for each grade is determined as follows:

$$\frac{W_1 + W_2}{453.59} \div \frac{A}{453.59} = \text{Pounds of material ground away per pound of grinding compound used}$$

in which
W_1 = Weight in grams ground away from valve
W_2 = Weight in grams ground away from seat
A = Total weight of compound used in grams
453.59 = Number grams in a pound

Table E shows the results obtained by applying this formula on a test of grinding compounds.

Table F summarizes the results obtained by applying the work factor to purchase. The product of Bidder G costs, per pound of grinding compound, 1.17 times that of Bidder I, but the cost of removing a pound of metal with the "G" compound is approximately $0.74 as compared with $1.47 to remove a pound of metal with the "I" compound. This does not take into consideration differences in the cost of labor as represented by Column b, which gives the pounds of metal removed per hour.

TABLE E

TEST OF GRINDING COMPOUNDS

Exhibitor	Grade	Grams Ground Away: Top	Grams Ground Away: Bottom	Work Factor
G	Fine	1.40	3.10	0.346
G	Coarse	2.90	3.10	0.461
H	Fine	1.10	1.20	0.177
H	Coarse	1.70	1.50	0.246
I	Fine	1.30	0.80	0.161
I	Coarse	1.50	0.90	0.184

TABLE F

WORK FACTOR APPLICATION

Bidder	Grade	a Bid Price per Pound	b Work Factor	Cost per Pound of Metal Removed Column a/b	Average
G	Fine	$0.2950	0.346	$0.8526	$0.7462
G	Coarse	0.2950	0.461	0.6399	
H	Fine	0.2650	0.177	1.4971	1.2871
H	Coarse	0.2650	0.246	1.0772	
I	Fine	0.2523	0.161	1.5670	1.4691
I	Coarse	0.2523	0.184	1.3712	

Hacksaw Blades. On a test of thirteen samples of hacksaw blades for hand frames, the number of cuts per blade varied between 8.33 and 22.33, and the number of strokes per cut varied between 4,602 and 8,523. The best set of samples gave 167 percent greater service than the poorest set, whereas the price of the best blades was only 10 percent greater than the price of the poorest. A similar condition existed in the hacksaw blades for machine use.

Testing Hacksaw Blades. In making the tests, hand frame blades were used in a special machine, and machine blades were used in another machine suitable for the heavier kind of work. Discs 3" in diameter were cut from annealed tool steel of the following chemical analysis:

Carbon	0.81 to 0.90 percent
Manganese	0.15 to 0.35 percent
Phosphorus	0.02 percent, maximum
Silicon	0.10 to 0.40 percent
Sulphur	0.03 percent, maximum

Each blade was used until unfit for further use. The failure of the blade was marked by breakage, cutting at an angle, or cessation of cutting. Both machines were operated at 60 strokes per min., the speed and pressure being constant during the test. In Table G, the data for three blades of identical description illustrate the method of computing the work value of each type and size of blade:

TABLE G

HACKSAW BLADE TESTS

Blade No.	Cuts Made before Failure	Average Strokes per Cut
1	14	6,000
2	20	8,000
3	11	4,000
	45	18,000
	Average 15	General Average 6,000

The following formula is used:

$$\text{Work value} = \frac{\text{Average cuts per blade}}{\text{General average strokes per cut}} \cdot 10{,}000$$

or, in the example given,

$$\frac{15}{6{,}000} \cdot 10{,}000 = 25$$

Numerous tests were made on this basis. Five records are shown in Table H to give an idea of the results obtained. Sample A gave 167 percent greater work value than sample E.

TABLE H

WORK VALUE OF BLADES

Tests	Cuts per Blade	Strokes per Cut	Work Value
A	17.33	4,602	37.7
B	22.33	7,560	29.5
C	16.33	6,412	25.5
D	16.00	8,523	18.8
E	8.33	5,912	14.1

V. KELVIN'S LAW

A. *Formulation*

What has come to be known as Kelvin's law was derived by Lord Kelvin, the eminent English physicist. Kelvin observed that the problem of constructing a power transmission line involved an interesting relation between the investment in the line and the power losses in transmission. The larger the wire the greater the investment, and hence the greater the fixed charges, but also the lower the transmission losses. In that event, Kelvin reasoned there must be some size at which the sum of the fixed charges and the cost of the transmission losses is a minimum. To find this minimum cost size, he set up the following type of formulation:

Let S = area of wire in circular mils
L = length of wire in feet
I = investment in the transmission line including poles, in cents per mil foot
X = percentage of I which represents the annual fixed charges
P = annual power loss per foot of wire of one circular mil in kwhrs
y = cost of power loss in cents per kwhr.

The annual fixed charges then are:

$$F = S \cdot L \cdot I \cdot X$$

The annual costs of transmission losses are:

$$T = \frac{P}{S} \cdot L \cdot y$$

The sum of these,

$$S \cdot L \cdot I \cdot X + \frac{P}{S} \cdot L \cdot y = M$$

becomes a minimum when,

$$\frac{dM}{ds} = 0$$

from which is found

$$S = \sqrt{\frac{Py}{IX}} \text{ (circular mils)}$$

Checking this equation dimensionally we find

$$S \text{ (circular mil)} = \sqrt{\frac{\frac{\text{kwhr}}{\text{foot/mill}} \cdot \frac{¢}{\text{kwhr}}}{\frac{¢}{\text{mil foot}}}}$$

$$S = \sqrt{\text{mil}^2}$$

It is to be noted that the above formulation is also obtained by equating the annual fixed charges to the annual operaing costs. Kelvin's law is sometimes stated in terms of this equation, that is, that the economic size is had when the annual fixed charges for a given size equal the annual operating costs of that size.

B. *Examples*

1. Transmission Line.

What is the most economical size of copper wire to transmit a current of 30 amperes at 10,000 volts? Assuming that the copper wire will cost 25¢ per pound and that a wooden pole line, including right of way, will cost $3,500 per mile, it is found that the total cost of the line will be approximately equivalent to $1.00 per pound of copper used. The weight of copper per mil foot is 0.000003 pound. At $1.00 per pound, the cost of the line per mil foot is I = 0.000003¢, and the annual fixed charges figured at 10 percent of I are 0.0000003¢ per mil foot or IX = 0.00003¢ per mil foot. Resistance of copper wire at 20° C is approximately 10.4 ohms per foot/mil. The resistance varies directly as the length and inversely as the area of the wire.

This resistance for a current of 30 amps results in a loss of

$$\frac{10.4 \cdot 900 = 9.36 \text{ kw}}{1000}$$

for each foot/mil of wire. Assuming in one year there are 8,760 hours and therefore if the current flows continuously the annual loss will be 9.36 kw · 8,760 hrs = 82,000 kwhr for each foot/mil of wire. At 2¢

per kwhr, the annual loss per mil for each foot of wire will be 164,000 cents. Accordingly, the size of the wire is:

$$S = \sqrt{\frac{164{,}000}{0.00003}} = 74{,}000 \text{ cir. mil}$$

The nearest commercial wire size is No. 1 B & S gage (83,690 cir. mil.).

If one can determine both the fixed charges and annual operating costs of a transmission line, Kelvin's law may also be used to determine the most economical voltage for line operation. This involves the determination of the voltage of transmission for a given amount of power over a given conductor.

In some circumstances this answer is modified by a number of factors such as coordinating this line with existing lines in the same system.

When the system voltage is known, the size of conductor may be the variable, and the most economical one may be determined as in the above example. It must be realized, however, that in a proposed system the voltage is as much of an unknown as the size of conductor, and a solution must involve both factors. In engineering practice, wire size is usually determined by (1) a certain allowable voltage drop, and (2) the current that can be carried by a conductor without dangerously overheating. While engineering judgment may lead to a widely different solution, an analysis by Kelvin's law will serve to point out any wide divergence of the construction decided upon from an economically good solution.

In practice too it will be found that many other factors must be considered, for example, the required outside diameter of wire for a given interspacing of conductors. This may need to be much larger than the size determined by Kelvin's law in order to prevent corona with its associated power loss. This requirement has led to the use of tubular or hollow conductors.

2. *Economic Life Span of Machinery*

Kelvin's law applies to the problem of determining the most economic life span of machinery. The factors involved are as follows. The annual depreciation of the investment (I) is $\frac{I}{N}$ where N is the number of years of the life span. Thus a machine costing $10,000, if it is to be retired in 5 years will be depreciated at the rate of

$$\frac{\$10{,}000}{5} = \$2{,}000 \text{ per year}$$

If the machine is to be retired after 4 years, it will be depreciated at the rate of $2,500 per year. The annual cost of operation of machinery is usually a constant (C) plus an increasing annual increment for repairs and maintenance (R). Thus after 3 years, for example, the cost of operation will be C + 3 R and after 5 years it will be C + 5 R.

Accordingly, the total annual cost (T) will be:

The annual fixed charges (k) which is constant

The annual depreciation $\left(\frac{I}{N}\right)$

The constant annual cost of operation (C)

The annual costs of repairs and maintenance (NR) which increases with the years.

Thus the total annual cost (T) becomes

$$T = K + \frac{I}{N} + C + NR$$

This is a minimum when

$$\frac{dT}{dN} = 0$$

Accordingly,

$$dT = 0 - \frac{I}{N^2}\,dN + 0 + RdN$$

or

$$\frac{dT}{dN} = -\frac{I}{N^2} + R = 0$$

$$N = \sqrt{\frac{I}{R}}$$

3. *A Fleet of Locomotives*

The Baldwin Locomotive Company issued a bulletin on September 10, 1937, entitled "The Motive Power Situation of American Railroads," in which an example is given of the economic life span of a group of three locomotives. The group cost $350,000 (I). The annual increment of Repair Cost (R) was $1,833. From which

$$N = \sqrt{\frac{350{,}000}{1{,}833}} = 13.85 \text{ years}$$

PART III

THE BUSINESS AS PART OF THE NATIONAL PLANT

INTRODUCTION

THE READER has certainly not failed to recognize the general assumption underlying the discussion in Part I and Part II, namely the assumption that the product is being sold.

If this were not the case, there would be little use in devising ways of visualizing the business or controlling its expenses.

But it is time now to consider if and under what conditions such an assumption is justified. This is why Part III of this study on the economics of industrial management will be devoted to some aspects of the problem of integration of the individual plant within the "national plant" as a whole.

It is impossible indeed to consume what is not produced and distributed to the proper place at the proper time, for the proper price. Neither is there any use, nor any economic possibility, in producing what cannot be ultimately consumed.

Production, distribution, consumption are *not* three distinct eco-

nomic activities but rather three phases of what could be considered the general economic flow of the national plant as a whole. Without the two other phases any one of the three is meaningless. Even more so, since any one individual within the national plant seldom acts in one capacity only. A farmer is a producer of food and also a consumer of manufactured products at the same time. A plant worker is a producer and also a consumer of food and of manufactured products. A dealer distributes the goods, but he consumes them too.

Maladjustments and conflicts may well appear between such groups, but they are *not* the unavoidable consequences of any fundamental opposition—only the accidental result of a lack of integration.

Maximum efficiency calls for *coordination* of efforts, which in turn means certain limitation of individual action.

The story is told of an old tailor who lived in a small town in New England. This was in the early days of the nineteenth century. The tailor had just finished a custom-made suit of clothes, which was made of expensive French silk, imported from Lyon.

The tailor's youngest helper went to deliver the suit, but in the evening he brought it back. The sleeves were too long—one inch. The customer wanted the suit ready for the following day, with the sleeves duly shortened.

By that time, as it was getting late, the tailor's two helpers were leaving. The younger one—who had just brought the suit back—was greatly excited and in a hurry as he was to be married the very next day and, indeed, was very much in love. As soon as he had given the customer's message, he disappeared. As for the older helper, it was his rule to leave early, since he had a long way to go. Besides, such alterations were none of his business as he was the cutter. The younger one did that kind of work.

After both had left, the old tailor, anxious to please his customer, who was a prominent man in the town, did the work himself although as a rule he no longer touched the needle for fear of straining his eyes.

The young boy was worried, however, because his wedding plans were interfering with his duty. Perhaps he saw there a bad omen, or was it that the tailor was a good boss and that he wanted to *cooperate*?

Anyway, the next morning, before daylight, he went to the shop and shortened the sleeves another inch, returning home quickly, in time for his wedding.

The other helper was equally fond of the boss and he also got up early, though not quite as early as his younger associate. He also

wanted to *cooperate,* and arrived at the shop after the younger helper's departure—but before the master's arrival. And he took another inch off the sleeves.

When the tailor arrived, the nice and expensive suit of clothes, of French silk, directly imported from Lyon, was damaged beyond repair—which somehow illustrates the difference between *cooperation* and *coordination.*

In all their enterprises, men strive for efficiency and at the same time remain jealous of their independence. Thus a conflict arises, which, according to the times and circumstances, is solved one way or the other.

It is a striking fact that every possible effort has been made during the last twenty years to develop to its maximum the coordination of efforts within the individual plant while so little has been done to develop the integration within the national plant. Scientific management would avoid the repetition of a mishap, as the one just related in the tailor shop, because it has organized the will to *cooperate* within the framework of *coordination.*

But, up to now, the principles of scientific management have not been adopted in the operation of the national plant as a whole on an adequate scale.

There are many reasons for this difference in treatment of the two problems in spite of their obvious similarity. One of the reasons often given is that the individual plants are submitted to a single authority, while the national plant is not.

The validity of this reasoning seems even more convincing if one considers that in some other countries the integration of the national plant has been realized by the substitution of a central authority for the individual ones. But this way of reasoning is a mistake, all the same. It assumes that integration is only possible through authoritarian methods and not through a free and self-imposed discipline—which assumption is in open contradiction with the facts of everyday life.

Individual liberty and personality do *not* necessarily suppose a total absence of rules, a limitless freedom of action to express themselves, nor does the adoption of a common goal and of a common timing of efforts necessarily infringe upon them. What really counts is the conditions in which the coordination of efforts is organized.

The members of a very distinguished club impose upon themselves countless restrictions as to their language, clothing, attitude toward the other members, etc. Yet they feel—and indeed, they are—infinitely

more free than the prisoners of a concentration camp who ignore such self-imposed rules.

Scientific management of the individual plant was, at first, regarded by quite a few as an unbearable regimentation of the individual. It is today recognized for what it is: the scientific integration of efforts by a freely accepted coordination of activity.

Another reason that has prevented the integration of the national plant on a more substantial scale is also, indeed, that such integration was just not possible until very recently.

The first step, before integrating the whole, was obviously to integrate the component parts—and scientific management is very young, not even universally practiced.

Also, there is a deep-rooted belief which works against the trend toward integration, namely, the belief in scarcity.

For ages, that is, from the dawn of civilization and up to the very last decades, the capacity to produce was so obviously below the ability to consume that it was utterly useless to worry about any kind of equilibrium.

A man who earns less than enough to buy his daily food does not bother very much with establishing a well-balanced annual budget of income and expense.

For ages, the only problem was to produce more and more. There was an apparently inexhaustible reservoir of ability to consume. But the ability to consume cannot be measured only in terms of needs; it must also be measured in terms of ability to consume under such conditions as to make production economically possible.

The economic crisis of the last decades show that the problem is a very actual one.

The periodical world conflicts and the international insecurity of today, by providing abnormal consumption channels, may make less apparent the potentialities of modern production.

At the same time, however, such conflicts provide an experimental demonstration of the impressive discrepancy between the capacity to produce and the ability to consume within the national plant when a proper degree of integration is attained. There can hardly be a more convincing demonstration than the sudden increase of production in the United States in the first years of the late world war, while the standard of living of the population, by and large, was actually safeguarded—especially if one considers that, at that time, a very substantial part of the population, indeed the most active part of the population, was actually waging war, i.e. consuming restlessly and producing nothing.

As a matter of fact, the economic stability attained during the war has been so impressive and the fear of the return of such a depression as that of the 1930's so common that various proposals have been made by influential industrial groups for improving the economic integration of the national plant.*

Such an integration is indeed existing today to a very substantial extent. The public utilities are an example of groups of industries integrated under the guidance of various authorities, such as the public utilities commissions. Trade associations, in as much as they foster a better organization of production, distribution and consumption in a given group of industries are also factors of integration. Standardization of production, which is at the same time a standardization of consumption, is another factor of integration. The Federal Reserve System is an integration, to a certain degree, of the banking business.

Given the degree of integration actually attained within the national plant, what should be the managerial economic policy of the business so as to be best adapted to today's conditions?

Furthermore, what are the trends toward a change in these conditions?

These are the problems which will now be explored.

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* See Chapter XV.

■ XIV

THE DOLLAR AS AN ECONOMIC YARDSTICK

JUST AS STEEL is weighed by the ton, wheat is measured in bushels, and butter is delivered by the pound, so business performances—income, expense, asset values, to mention a few—are estimated in dollars. The businessman measures the extent of his success or of his failure in terms of dollars. It is in terms of dollars that he makes his plans. The dollar is his economic yardstick.

Usually yardsticks are essentially characterized by their fixity. The size of the bushel in 1939 was the same as it is today. No one speaks of a ton 1936, of a ton 1948, which would imply that the ton 1948 is not the same as the ton 1936 (although one must be careful to specify the short ton or the long ton). Transactions and accounting would become much more difficult if such yardsticks as the ton, the bushel, etc. would vary. Yet the economic yardstick, the dollar, is a variable one. Today we speak of the 1939 dollar and the 1948 dollar—implying by this that the dollar as an economic yardstick has changed so sub-

stantially between 1939 and 1948, that the 1939 dollar and the 1948 dollar are two different units of measurement. This implication is unfortunately correct. Disturbing as such a fact may be, it is a fact and it is of the utmost importance to the businessman to recognize it as such. In as much as the economic yardstick, the dollar, does vary, the businessman must be aware of its variations and be able to correct their effects as much as possible. It is not always clear to the businessman that when prices change, this phenomenon may be due to one of two causes: either a fluctuation resulting from usual business market operations or a variation in the dimensions of the yardstick (the dollar) used to measure business activity.* Two examples may assist in showing the relation between money and goods. In the first place, let us take the case of a manufacturer of any commodity such as automobiles. In a given year, say 1920, if he produces 100,000 automobiles at a total expense, for materials, wages, interest, dividends and all other charges, of 100 million dollars, the automobiles are said to cost $1,000 each. Let us assume that instead of using dollars, the manufacturer were to use certificates of ownership in the goods produced and that all wages, salaries, materials, interest, dividends, etc. were paid by distributing these certificates of ownership instead of dollars. All those who supplied materials, labor, and other services would then hold certificates of ownership in the 100,000 automobiles produced instead of having money in the bank. Let us assume that a standard certificate be established as equal to one automobile. The entire year's production would therefore be represented by 100,000 standard certificates, each one of which is equal to one automobile so that the owner of such a certificate could go to the warehouse and claim one automobile. It may be written then that;

$$100{,}000 \text{ standard certificates} = 100{,}000 \text{ automobiles}$$

or

$$1 \text{ standard certificate} = 1 \text{ automobile}$$

This would give a value of $1,000 to each certificate of ownership in 1920. Let us assume that in another year, say 1930, the manufacturer improves his methods of manufacture such that he produces 120,000 automobiles with the same labor force and the same interest charges, but more materials cost, so that his total expenses are 108 million dollars. The cost of one automobile will then be $900. If now instead of using money to pay all expenses the manufacturer would use cer-

* See note, page 339.

tificates of ownership, as he did in 1920, on the basis that one standard certificate shall be equal to one automobile, then he will distribute 120,000 certificates in payment of all expenses, and each standard certificate will be a claim to one automobile. But the reader will object at once to the use of a standard certificate the one year worth $1,000 and a standard certificate the other year worth $900. Such use of a *standard* does not make sense, he will say; the two certificates should be of the same value. But are they not? They are each worth one automobile, of the same kind in every respect. Yes, the reader will say, but they are not of the same value in dollars, for the certificate issued the one year, 1920, was worth $1,000 and the one issued the other year, 1930, was worth $900.

But let us not forget that the value of the certificate is, by definition, "one automobile" (of a specific type, size, and quality). The decrease in the value of the certificate over the years, as expressed in dollars, simply shows that the price of each automobile has gone down. This is a case of price fluctuation. In our example the fluctuation is due to technical progress which reduced the cost of production. The second example used to show the relation between money and goods will now illustrate what happens in a fundamentally different situation.

We will consider the case of issuing certificates or claims to goods not paralleled by the production of goods, which the attentive reader will realize is bringing us nearer to an understanding of what is happening in our economy. For instance, when one borrows money at the bank, he receives a credit or deposit in his account against which he can issue checks in purchasing goods and services. By creating such credits or deposits, the banker creates claims to goods in excess of those already issued in the form of wages, salaries, interest, dividends, and other charges on production when the goods were produced. This process causes *variations* in the value of the dollar. Whenever the number of claims to goods or certificates of ownership of goods, which is what the dollar is, become greater than the goods to be claimed, then the value of the claims to goods, the dollar, becomes less; the dimension of the yardstick is changed. Let us consider the following situation by way of illustration. Suppose the automobile warehouse of the previous example caught fire and one-half the autos were destroyed. Instead of honoring the first 50,000 certificates presented and delivering the 50,000 remaining cars to their holders, leaving the other 50,000 certificates worthless, it would be provided that since half the cars are destroyed, each of the remaining cars is

now worth two certificates. This means that the value of each certificate has been reduced to half the value it had when issued. If you think in terms of dollars, you may argue that the claims to goods, the certificates issued, being in excess of the goods they represent, the value of the claim to goods, the certificate, has gone down. Thinking in these latter terms will help us to understand a very important phenomenon of our wartime economy, which has much significance to the businessman, be he manufacturer or merchant. During the war we produced great quantities of goods and at the same time issued corresponding certificates of ownership of such goods. The majority of the goods produced in the period 1940 to 1945 were military goods, most of which were destroyed. But the certificates of ownership of such goods are still in existence and are being used to buy automobiles, washing machines, houses, and many other commodities. These certificates also increase in amount in time because of accumulated interest charges and the operation of our banking credit system subsequently referred to. So the result is that the unit of value, the dollar, in terms of which these certificates are written, has declined materially. The 1948 dollar has substantially less value than the 1939 dollar.

The *variation* * in the value of the dollar is not to be confused with the *fluctuation* † in prices due to the activities of the market place. Many businessmen are much more interested in the *fluctuations* in prices which they carefully follow day by day than in the *variation* in the value of money. But there are a number of practical reasons why the businessman should be concerned about the variation in the value of the dollar, especially when it tends to stabilize at lower levels as is indicated at the present time.

This chapter is mainly concerned with a study of today's conditions in the United States. There have been other times, in America and in other countries, in which changes in the value of money have taken place. Some of them will be briefly referred to in this chapter. But it should be noted that we are facing today an entirely different and new situation which is not comparable to former and apparently similar conditions affecting the value of the dollar. It is true, for instance, that there were fluctuations in prices in the early twenties that are reminiscent of the ones we are presently witnessing. But the conditions inherent in post–World War I were fundamentally dif-

* Variation is "change in condition, character, degree, etc."

† Fluctuation is "continual change from one course, position, condition, etc., to another."

ferent from those found in post–World War II, so far as the United States is concerned. American effort in terms of destruction suffered and debt contracted was not comparable to that experienced in World War II. A comparison with European countries would be more appropriate but of limited value. In World War II, European countries went much farther along the road to exhaustion and their conditions can not well be likened to our own. The most fruitful comparison is probably between post–World War II in the United States and post–World War I in France or Britain. But again there are so many fundamental differences in the economic development of these three countries and also in the world's political developments after World War II as compared to what they were after World War I that it is difficult to draw any valid comparisons. Accordingly we are compelled to study directly today's conditions in the United States with only occasional reference to the experiences of other countries.

So we may state that while some variation in the value of money has been experienced from decade to decade, the very substantial variation in the value of money experienced in the past decade is something new in modern American history. It is the direct result of the great inflation that followed World War II.

What is inflation?

In a statement before the Joint Committee on the Economic Report, Special Session of Congress, November 25, 1947,* Marriner S. Eccles, the then Chairman of the Board of Governors of the Federal Reserve System, defined inflation as,

". . . the condition which exists when effective demand exceeds the over-all supply of goods and services." †

This definition indicates that there are two possible causes of inflation, which may, of course, be coexisting:

1. Inflation may result from a decline in the supply of goods and services, but with a steady demand.

2. Inflation may result from an increase in effective demand, but with a steady supply of goods and services.

During the war, however, while the supply of goods and services available to civilians was not sufficient to satisfy the demand, government controls of prices prevented inflation.

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* Reprinted in the *Federal Reserve Bulletin*, December, 1947.

† "Effective demand" is the subject of the next chapter. It will show how effective demand can be best measured for a given country by an estimate of the total population and of the inhabitants' purchasing power.

After the termination of the government controls of prices, a rapid industrial reconversion enabled production of civilian goods to re-establish itself. The supply of goods and services in the United States was very soon equal to or even larger than before the war, even if one takes into account the increase of population and the backlog of unsatisfied needs.

This then suggests that the inflation in the United States following World War II was *not* due to a relative decline in the supply of goods and services, but *was* due to a relative increase in effective demand. This will now be shown to be the case by studying the origin, the extent, and the consequences of the post-World War II inflation in the United States.

ORIGIN OF INFLATION

An individual or a business that spends more than it earns will, in the final analysis, go bankrupt. A national government generally does not. A government will face excessive expenses by artificially increasing its supply of money by "inflating" it.

The process of inflation as a way for a nation to face otherwise unbearable expenses is as old as economic civilization itself. Solon, in Athens, during the sixth century B.C., was responsible for what is probably the first recorded inflation of money. Later on, it was through inflation that the Roman magistrates financed the Punic Wars. Further examples occur in almost every century. In the Middle Ages, tampering with the money was one of the most generally adopted means of financing used by many European kings and feudal lords. The French Revolution proclaimed new principles of freedom in Europe but, financially, it followed the old routine of inflation by printing millions and millions of soon worthless *assignats*. The financial history of the European and Asiatic governments during the first half of the twentieth century is too well known to need comment in this respect.

However, while the process of inflation is as old as the use of money, the technique of inflation has changed considerably. In times past, the technique followed by governments was simply to reduce the size of the coins. For obvious psychological reasons, they soon learned to practice a more refined technique: the coin would not change in size; the proportion of precious metal (gold or silver) to the other less expensive metals would decrease. Such a change is not generally noticed by the public.

But with the general use of paper currency, inflation became a simple technique of printing inexpensive banknotes in greater number

and value than usual. This was essentially the way inflation developed in most countries during and after the wars. (Table XLVI.)

To a certain extent, this practice was also followed in the United States to help finance World War II. The circulation of currency in the U.S. increased from 6.4 billions of dollars in 1939 to 26.7 billions of dollars in 1946.

TABLE XLVI

INFLATION IN VARIOUS COUNTRIES DURING WORLD WAR II

	FRANCE Billions of Francs		UNITED KINGDOM Billions of Pounds Sterling		AUSTRALIA Millions of Australian Pounds		CANADA Millions of Canadian Dollars		UNITED STATES Billions of Dollars	
	1939	1946	1939	1946	1939	1946	1939	1946	1939	1946
Currency	151	722	.50	1.38	54	211	281	1,095	6.4	26.7
Deposit money	59	704	1.25	3.82	149	492	2,662	5,980	29.8	83.0
Total money supply	210	1,426	1.75	5.20	204	703	2,944	7,075	36.2	109.7

Source: International Financial Statistics, Washington, D. C., January, 1948.

But, as is well known, the total supply of money in a modern country is a complex total of currency (essentially paper currency) and bank credits or *bank deposits.* (The reader who is not familiar with the concept of bank deposits as part of the total supply of money is referred to textbooks on banking.)

In some countries, paper and metal currency is still the most generally used form of money. In other countries, on the contrary, the currency is largely in the form of bank deposits. Table XLVII shows how the United States compared in this respect with another country, France, for instance, in 1939.

Such figures show how fundamentally different the situations were in the two nations. In France, in 1939, almost three fourths of the total money supply was in currency. In the United States, however, in 1939, currency represented less than one fifth of the total money supply.

Inflation in the United States had to follow a process adapted to the financial structure of the country. The mere printing of additional currency would obviously not have served the purpose even if it had been technically and legally desirable and permissible.

In fact, the technique followed was a very refined utilization of the flexibility of this modern type of money, the bank deposit. Di-

TABLE XLVII

MONEY SUPPLY IN THE UNITED STATES AND FRANCE (1939) *

	France	U.S.	France	U.S.
	(Billions of Francs)	(Billions of Dollars)	Percent of Total Money Supply	
Currency	151	6.4	71.9	17.6
Deposit Money	59	29.8	28.1	82.4
Total Money Supply	210	36.2	100	100

* From, "International Financial Statistics," Washington, D. C., January, 1948.

rectly or indirectly, a substantial percentage of the bank deposits of the country were put at the disposal of the nation through the purchasing of Federal Government bonds by individuals and banks.

The financing of World War II meant that the Federal Government must raise about 398 billions of dollars for the six years 1940-1946. Only 176 billions, or 44 percent, came from taxes. The remainder, 222 billions or 56 percent, was raised by borrowing.

Of these 222 billions, approximately 90 billions, or almost 23 percent of the 398 billions raised during the six war years, was raised by selling government securities to the commercial banking system (including those purchased by the Federal Reserve Banks).*

This resulted in a large increase of bank-held government securities. Table XLVIII illustrates the situation from 1939 to 1947.

TABLE XLVIII

ALL BANKS IN THE UNITED STATES INVESTMENTS

(Millions of Dollars)

	Total Investments	U.S. Govt. Obligations	Other Securities
Dec. 31 1939	28,719	19,417	9,302
1940	30,422	20,972	9,449
1941	34,511	25,511	8,999
42	54,231	45,951	8,280
43	73,365	65,932	7,433
44	93,446	85,885	7,561
45	109,865	101,288	8,577
46	96,050	86,558	9,491
47	91,909	81,186	10,723

Source: ***Federal Reserve Bulletin.***

* Previously quoted statement by the Chairman of the Board of Governors of the Federal Reserve System.

During the same period, the money in circulation varied as shown by Table XLIX.

TABLE XLIX

TOTAL DEMAND DEPOSITS (ADJUSTED) AND CURRENCY OUTSIDE BANKS
(*Millions of Dollars*)

Dec. 31 1939	36,196
1940	42,270
41	48,607
42	62,868
43	79,640
44	90,435
45	102,341
46	110,044
47	113,499

Source: *Federal Reserve Bulletin.*

It is interesting to compare these data. This comparison is shown in Figure 64. It shows that the increase in bank-held government securities, starting with the war in Europe in 1939 was associated with an increase in total money in circulation. But it also shows that a decrease in bank-held government securities, after 1945, was *not* associated with a decrease in total money in circulation.

This underlines the very peculiar character of inflation in the United States. In a country where the inflation is mainly due to an increase in currency, its effects are more immediately felt but, barring of course any further inflation, they are soon dispelled. In a country where the inflation is mainly due to a very refined use of the delicate modern apparatus of bank credits, as was the case in the United States, the effects of inflation are somehow delayed, almost unnoticed, but they are then felt for a long time and finally result in substantially higher price levels. Inflation acts in some respects as a time bomb would. It does not explode suddenly but it is there, and is due to explode. In fact, inflation was not felt in the United States until many months after the end of the war and the termination of wartime controls although, as Figure 64 shows, a potential inflation already existed.

Then, after it began to be felt, inflation developed and was increasingly felt, although the exceptional circumstances that provoked it had ceased to exist. The reason is that the potential inflation contained in the expanded debt was slowly converted in more and more

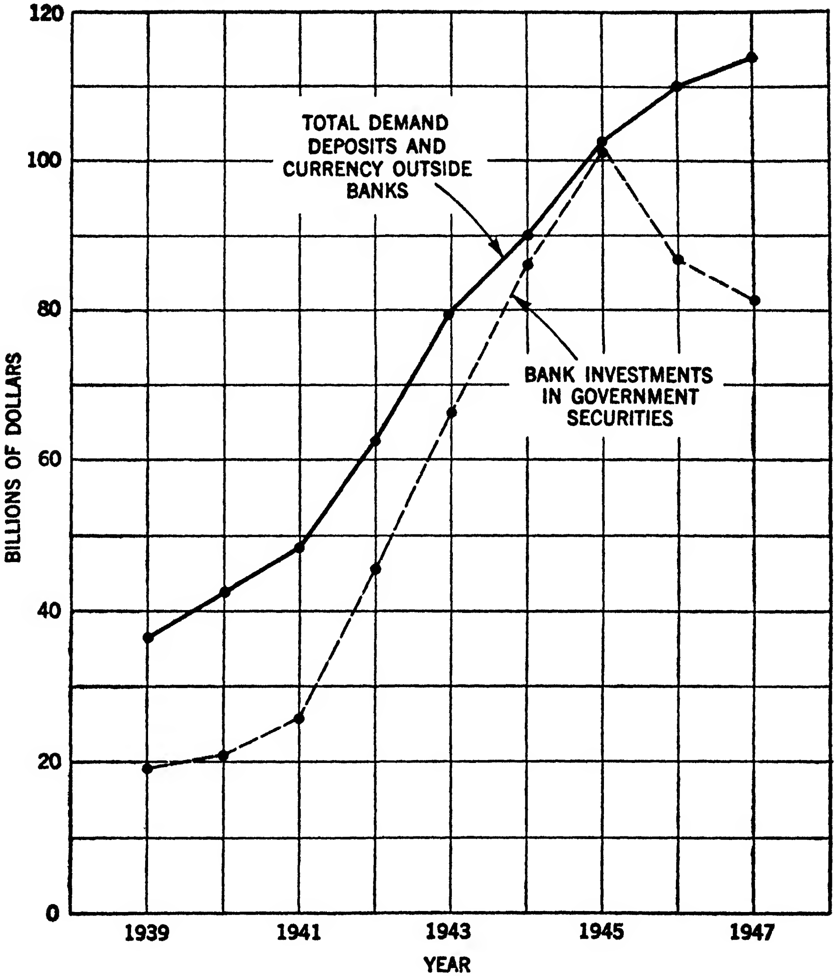

Figure 64. Comparison of Total Bank Deposits and Currency Outside Banks with Bank Investment in Government Securities for the U. S. A., 1939–1947

inflation of money in circulation by the complex processes of debt retirement, debt support by the Federal Reserve System, increase of bank deposits, increase of bank reserves, and the extension of new bank credits.

These processes, which could be compared to the melting of snow and ice into the high waters of the spring season after a long and hard winter, were recently described as follows by the Chairman of the

Board of Governors of the Federal Reserve System, Thomas B. McCabe, in a statement before the House Banking and Currency Committee: *

Sales of United States Government securities in the market by banks and others have not been absorbed by purchases on the part of other investors. In order to keep the prices of Government securities from declining, the Federal Reserve System has continued to carry out its wartime responsibility of supporting the market by buying at relatively stable prices securities offered for sale and not purchased by others. The result of these purchases by the Federal Reserve Banks is to supply additional reserve funds to banks. Because of the fractional system of reserve requirements, these new reserves in turn provide the basis for an increase in bank credit that may be many times the amount of new reserves obtained.

In the postwar period these reserves supplied the basis for an increase in bank credit in response to an active demand for loans to finance the operations and expansion of the business system in an era of high demand, accelerated activity, rising costs, and rising prices. There is ample evidence that bank credit is also being used for purposes ordinarily served by the capital market. As a result, despite a reduction of 25 billion dollars in the volume of Government securities held by commercial banks, deposits and currency held by the public have increased by an additional 15 billion since the end of 1945. This has been largely the result of an increase of 15 billion in bank loans.

EXTENT OF INFLATION

Many essays have been written as to the value of today's dollar in terms of yesterday's dollar. Some have estimated that the dollar, 1948, for instance, is worth about 40 cents, 1939. Others dispute the point and argue that such an estimate is too low or too high for such and such reasons.

Although such estimates may give a useful approximation of the situation as a whole, it should be clearly understood that the extent of an inflation cannot be measured in such simple terms. The reality is much more complex, due to conflicting psychological, monetary, social, and economic factors.

If, by chance, it was estimated that the unit of length measurement, the foot, is too long and if, by chance, it was ordered by Act of Congress to shorten it by one third, it would take years before the population conformed to the use of the new length of the foot. It would probably take more than a generation.

* On August 2, 1948. Reprinted in the *Federal Reserve Bulletin* August, 1948. See also a similar statement by Marriner S. Eccles, then Chairman of the Board, in *Federal Reserve Bulletin*, December, 1947.

In the same way, psychological factors influence the acceptance of the results of inflation. For the average citizen, "a dollar is a dollar" and he is inclined to believe that prices are going up rather than to realize that the economic yardstick with which prices are measured is changing—as it is, in fact. Is it not difficult, sometimes, when sitting in a train, to decide whether one's own train or the one coming in the opposite direction is moving? How then can the average citizen who has to pay a dime instead of a nickel for his subway fare know for sure whether, in the final analysis, the price of the fare has increased or whether his dime of today is worth about the same as his nickel of yesterday?

Such psychological factors will act as a brake against inflation, the extent of which, as measured by the price level, will lag behind its extent as measured by the increase in the volume of money in circulation.

Indeed, such psychological factors will not be equally influential in the various sections of the national economy. The wholesaler, the importer, the industrialist, the stock market operator, the labor unions, all follow the real monetary situation much more closely and adapt themselves much more quickly than does the general public.

Social factors also are influential. Governments cannot allow inflation to be felt too quickly or to its full extent in every field. For instance, experience shows that in every country such control as the rent control among others is maintained over a long period of years after the start of an inflation.

The arising of new economic conditions, the actual velocity of money circulation, and extensive new technical developments may also be influential in counteracting the effect of inflation, and it is always difficult to evaluate the relative influences of such conflicting factors. Therefore, neither the price level of specific commodities alone nor the increase in total money in circulation alone can be used to determine the extent of inflation. Even less so, if inflation is due, as it is in the United States, to the slow and still expandable transformation of a potential inflation into an actual one.

The extent of inflation, therefore, cannot be expressed by a definite ratio, and no attempt should be made to do so. Moreover, it is useful to determine its order of magnitude and its probable future evolution, which will now be attempted.

On December 31, 1947, the Bureau of Labor Statistics published the following indexes of the cost of living (Table L).

TABLE L

COST OF LIVING INDEXES

Value as of Dec. 31, 1947, of:	
Consumers' price index (1935-39:100)	167.0
Retail prices of foods (1935-39:100)	206.9
Wholesale prices (1926:100)	
All commodities (1939:77.1)	163.1
Farm products (1939:65.3)	196.7
Foods (1939:70.4)	178.4
Metal and metal products (1939:94.4)	152.1
Building materials (1939:90.5)	191.0

Such figures show that the general price level on December 31, 1947, was, on the average, slightly more than double of what it was before the war. But, at the same time, the total money in circulation (total demand deposits adjusted and currency outside banks) had increased from:

$ 36.2 billions on Dec. 31, 1939
to $113.5 billions on Dec. 31, 1947

which means an increase of about 300 percent.

The national income * had increased from

$ 72.5 billions in 1939
$202.5 billions in 1947

which means an increase of about 280 percent.

The amount of liquid purchasing power in the hands of the public, that is, currency, bank deposits, and government securities was, by the end of 1947, aggregating $236.8 billions, which was more than three times the amount held in 1939, namely $69.0 billions.†

Finally, the bank-held government securities which amounted to $19.4 billions in 1939 had increased to $81.1 billions in 1947, an increase of 400 percent or more.

Such figures show that, on December 31, 1947, the prices, as compared to their prewar level, had just about passed the 200 percent mark; the actual monetary inflation had reached the level of about 300 percent; and an even greater inflation, a potential one, was indicated by an increase of the bank-held government securities by more than 400 percent.

It could therefore be said, in answer to the two questions that were asked at the beginning of this discussion, that, on December 31, 1947:

* For a definition of the "national income," see Chapter XV.

† Figures published by the *Federal Reserve Bulletin*, June, 1948.

1. The order of magnitude of actual inflation was somewhere between 200 and 300 percent.

2. A potential additional inflation indicated a threat of further inflation.

Events since December 31, 1947, have confirmed this view. Indexes of prices have very substantially increased. Up to the later part of 1948, and in his message to Congress, delivered on January 5, 1949, the President mentioned inflation as being still a threat to the national economy.

CONSEQUENCES OF INFLATION

Socially, a substantial inflation has very serious consequences. It threatens the way of life of whole segments of the population, creates maladjusted situations, and causes a general feeling of insecurity and discouragement—easily converted into despair and political agitation, as the experience of other countries has shown.

The economic consequences—which are the ones we are concerned with in this book—deserve also the most serious consideration. They are of two kinds: short run effects and long run effects.

I. SHORT RUN EFFECTS

Prices continuously change, even if there is no inflation. But the changes in the absence of inflation are of much lesser magnitude, as shown, for instance, by the variations over a period of years of price indexes. Table LI shows such variations for a few indexes chosen at random.

TABLE LI

VARIATION OF FOUR SIGNIFICANT INDEXES

	Absence of Inflation Period 1929–1940		Value as of Dec. 31, 1947 under the Impact of Inflation
Consumers price indexes (1935–1939: 100)	Highest 1929:	122.5	167.0
	Lowest 1933:	92.4	
Retail price of foods (1935–1939: 100)	Highest 1929:	132.5	206.9
	Lowest 1933:	84.1	
Wholesale prices of farm products (1926: 100)	Highest 1929:	104.9	196.7
	Lowest 1932:	48.2	
Wholesale prices building materials (1926: 100)	Highest 1929:	95.4	191.0
	Lowest 1932:	71.4	

Such figures illustrate how much smaller is the range of variations due to a change in general economic conditions than when it is due to inflation. The comparison is illustrated by Table LII.

TABLE LII

GREATEST VARIATION OF FOUR SIGNIFICANT INDEXES

(Variation from the base years, 1926 or 1935–1939)

	Absence of inflation (1929–1940)	Inflation (1947)
Consumers price index	22.5	67.0
Retail prices of foods	32.5	106.9
Wholesale prices—farm products	51.8	96.7
Wholesale prices—building materials	28.6	91.0

Such a difference explains by itself why adjustments, even if they may cause hardships, are easier in the case of simple economic fluctuations than in the case of inflation.

Experience shows that, after an inflation, it takes a long time before prices adjust themselves to a new but higher level of equilibrium. For a long period, the economy is disturbed. The situation is somewhat comparable to the one that would exist if the inch measure of length were, by successive and progressive steps, reduced to a half or a third of its original length, especially if the reductions were not clearly defined and not universally recognized.

One of the most widely publicized consequences of the instability originated by inflation is the so-called wage-prices spiral. But this is only one side of the question. What happens, in fact, is that the exchange of goods and services is based on a yardstick of changing value.

The value is changing in time because the effects of the inflation are delayed and progressive. The value is even changing from place to place and transaction to transaction because of psychological factors. Some individuals would ignore the extent of the inflation, for lack of information, while others may be inclined to exaggerate its real magnitude.

Furthermore, social and political consideration may cause public bodies to take various measures delaying the results of inflation, such, for instance, as the control of prices. It even happens that price control will be limited to some fields, the rent of housing, for instance, while others are left free, which creates permanent conditions of maladjustment.

In the end, a new equilibrium is found, barring further economic disturbances. But the European experience after World War I shows that it takes a long time.

Meanwhile, the businessman has to adjust himself the best he can to a temporary disequilibrium. No general rule can be given for meeting such a situation, characterized by a complete lack of logical behavior.

II. LONG RUN EFFECTS

Once the situation is more or less stabilized, a rational treatment can be considered. Even before such a stabilization becomes an actual fact, it is advisable for the businessman to prepare the way for adjusting himself to the new conditions to be expected.

The first step is to determine within reasonable limits of accuracy the order of magnitude of actual inflation after it has reached its level of equilibrium. We have seen in the first part of this chapter how a reasonable estimate may be attempted.

The second step is, then, to evaluate the long run consequences of such a change in value as far as the assets, liabilities, and proprietorship of the business are concerned.

A. *Assets*

Some assets such as cash, receivables, and inventories, more or less adjust themselves to the new value of the money. But the fixed assets purchased before the inflation period are still accounted for at their old value. This creates a double problem.

First problem: The balance sheet does not reflect the true situation. There is a systematic undervaluation of actual assets. In some instances, a reevaluation of assets might be justified. The surplus resulting from this reevaluation should, of course, be separated from other kinds of surplus as it is really the result of an accounting adjustment, not an actual profit.

Second problem: The profit and loss statement reflects the profit (or loss) which is the difference between the sales and the cost of goods sold, plus other expenses. Some of the costs are still accounted for at the former value of the money, especially the depreciation. The result is that the profit is partly artificially inflated (or the loss unduly minimized). Some manufacturers are well aware of the situation and have suggested an additional depreciation based on the replacement value of the assets. This method, however, is in direct opposition to the very nature of depreciation.

Depreciation is an allocation of a capital expense over a period of years.* It is, therefore, a very definite and stable amount. To base depreciation on the replacement value, which may change from day to day, is introducing a dangerous element of instability in accounting and should not be encouraged. There is a way out of the difficulty by creating a "reserve for increase in replacement price of assets."

A reserve, by definition, is an amount of money put aside to face a future liability or expense, the amount of which is or is not precisely known. This is exactly the case. Due to the devaluation of the money, the manufacturer, through depreciation, is nominally reconstituting his capital but, *really*, he is *not*. The nominally accurate but really insufficient depreciation expense causes him to use part of his original capital to increase his apparent profit.

The exact amount of capital money being actually made part of the profit is not accurately known. Its best approximation will come at the time of replacement, by consulting the replacement value of the machinery as compared to its original value. Even at that time, due to technical changes and certain other causes, an exact appreciation of the facts will probably be impossible. One should endeavor to arrive at a reasonably close estimate. Among others, three factors should be considered:

1. How comparable to the former asset is the replacement asset? Because it is obvious that if the increase in price is due not only to the devaluation of the money but also to the decision to purchase a better machine, the problem is not at all the same one.

2. What is the salvage value of the machine? Because, due to inflation, in some cases the salvage value may be much more than could have been expected, thereby reducing the capital loss.

3. How was the purchase of the original asset financed? If it was financed by the issue of bonds, the devaluation of the money acts both ways: on the one side on the real value of the depreciation and on the other side on the real value of the amortization of the debt. In this case again, the problem is entirely different. More will be said on this question in the section on liabilities.

But enough is known now to see that there is a difficult problem of estimating the amount by which the depreciation cost should be increased. It is practically impossible to make such an estimate before the replacement value of the asset is exactly known. It seems advisable, therefore, to keep the concept of the depreciation, its clarity

* See Chapter IX.

and fixity, and to compensate a possible loss in capital by the establishment of a reserve.

When the amount of the loss in capital can be computed, such an amount is transferred to a surplus amount and the remnant of the reserve, if any, is part of the current profit—like a tax refund, for example. It should be clear that neither method of accounting—by supplementary depreciation or by creation of a new type of reserve—is acceptable to the Tax Administration. From the point of view of Federal taxes, the profit should be computed on the basis of the nominal depreciation (purchase value).

This difference in point of view is not only due to the legitimate desire of the Administration to collect the maximum taxes as opposed to the not less legitimate desire of the taxpayer to reduce his load to the minimum. There is a really deep-rooted difference in point of view due to their respective concepts of business enterprise.

For the Tax Administration, a business is a more or less temporary venture, ended by the life of the partners or the dissolution of the corporation. But for the businessman, his enterprise has a definite character of permanence. He likes to think *sub specie aeternitatis.* He is not only concerned with recovering his capital by the use of an adequate accounting system of depreciation. He is also and even more concerned with the renewal of his machinery when it becomes obsolete or worn out, and with the self-perpetuation of his enterprise.

It is not certain that the Tax Administration will change its point of view in the foreseeable future, although a congressional joint committee on the Economic Report recently inquired into this question (see *New York Times,* December 8, 1948). But, independently from any consideration of taxes, it is good policy to present the results of a business as they really are.

A depreciation based exclusively on the purchase value means, in time of inflation, a depreciation based on the former value of the money. Profits computed after such a depreciation are unduly inflated by an apparent increase of net income and a real loss in capital.*

B. *Liabilities*

Conversely, the debts of the business, if contracted before the inflation, are, in fact, substantially reduced. This, in itself, might automatically compensate for the effect of inflation on depreciation. If the

* For a full discussion of the subject (along lines substantially different, however) see S. J. Broad, "The Impact of Rising Prices Upon Accounting Procedures," in the *Journal of Accountancy,* July, 1948.

assets being depreciated have been bought on borrowed money, there is obviously no justification for a reserve "for increase in replacement price of assets."

C. *Proprietorship*

This is where inflation may have its most disturbing effect. The decrease of the value of money means that for the same volume of production, there is a corresponding increase in capital needs. Directly or indirectly, the business's capital should be increased either through reinvestment, borrowing, or non-distribution of dividends.

For most businesses, the stimulation given by the very process of inflation, creates a surplus of profits that will compensate, to some extent, for the loss in the real value of the capital.

For corporations, however, the problem remains of retaining such surplus in the business instead of distributing it as dividends. During the postwar years, 1946-1947-1948, most of the United States corporations have pursued a policy of retaining in the business a very substantial part of the earnings, as previously shown.* Such a policy may somehow help solve temporary difficulties in financing the business but, in the long run, it may contribute to a reduction of that portion of the national income which is used for consumption purposes. It may be a step toward reducing the "effective demand" below the level required for the continuation of healthy economic conditions. This calls attention to a point, the importance of which cannot be overemphasized.

This chapter, discussing inflation, has shown the dangers of the conditions in which "effective demand exceeds the over-all supply of goods and services." But the reverse condition in which the over-all supply of goods and services exceeds effective demand is just as dangerous, if for opposite reasons. It is the origin of this unhealthy economic stagnation called a depression.

How can effective demand be evaluated and forecast by the businessman? What are the main factors responsible for a harmonious relationship of effective demand to supply of goods and services? Such questions will be studied in the following chapter.

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* See Chapter III.

XV

PRODUCTION AND EFFECTIVE DEMAND

ACCORDING TO A STUDY made by the Federal Trade Commission in 1939, the sum of production wages or salaries and of direct material expenses, in the gray-iron and malleable iron castings manufacturing corporations, represented only 59.27 percent of sales. Net profit before taxes represented 8.75 percent of sales. The remaining 31.98 percent were needed to cover the other expenses, such as depreciation, selling, advertising, administrative expense, etc.

Similar studies, published from time to time by the Federal Trade Commission * for all groups of industry, show similar results. Although there are, of course, great differences among industries and for any industry from year to year, it is generally the case for all industries that between 30 and 40 cents of each dollar of sales is used to pay such expenses as depreciation, selling, advertising, administra-

* Federal Trade Commission's "Industrial Corporations Reports."

tive expense, and, generally speaking, expenses which are almost entirely *total constant expenses.*[*]

This illustrates the unstable condition of equilibrium of modern industry. In former years, the sum of production wages or salaries and direct material expenses, i.e. essentially *variable expenses,* represented most, if not all, of the total expenses. Thus, in former years, if sales of a new product were slow in developing or if an already well-marketed product faced a recession in sales, the manufacturer was able to face the situation with no greater trouble than a smaller profit than expected.

During the past generation, things have changed fundamentally. Modern industry, through the application of entirely new methods of production and distribution, opens practically unlimited possibilities of increasing the population's standard of life by producing greater quantities of goods at an ever decreasing total cost. Yet such new methods require a minimum level of production to support the burden of the continuously increasing proportion of *total constant expense.*

The pilot of a modern jet plane travels as fast as sound. Unlike the old-time horseback rider, however, he cannot slow his pace at will, lest he fall and die. The span of his wings supports him only above a given minimum speed.

Mass production, in like manner, must be maintained above a given minimum rate or else the enterprise goes out of business.

The businessman ought to know this minimum rate of production —the break-even point of his business below which "speed" he cannot operate. But it is not sufficient for him to know only what is the minimum rate of production required, he also must know how to find a market for such a production.

How can sales be maintained at the rate required to make production economically possible? Who will buy at a sufficient price in sufficient quantity?

Better presentation of the goods, more clever advertising, wiser pricing and, generally speaking, a better marketing policy enable a given business, operating either directly or through jobbers in a given market, to maintain or increase its share of the total business as compared to its competitors' share.

Even if the competitors' resistance tends to limit such effort, the limit is always more or less a flexible one. The more dynamic enterprise has a good chance of being successful in expanding its market.

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[*] For the distinction between variable and constant expenses, see Chapter IV.

There is, however, a second limit to its efforts in this direction. This second limit is determined by the *effective demand,* meaning the demand for a product which is supplied at a price the customer can and will pay. Beyond this second limit, the business cannot expand, whatever its vitality, whatever its influence on the consumers' tastes and wants—even if it were able and permitted by law to eliminate all its competitors from the market.

It is of vital importance for the businessman to know how to approximate the effective demand. It is the purpose of this chapter to deal with this question. Obviously, the more customers there are and the more money they have to spend, the more effective demand there is. It is necessary, therefore, to study the two factors which, economically speaking, determine the effective demand, namely:

I. The population
II. Its purchasing power.

I. POPULATION

There seems to be a general pattern of growth of populations. Such a pattern will be studied in the following chapter.* Its very existence suggests the possibility of forecasting future conditions by extrapolation. The danger of such extrapolations is obvious and well known. But, if carefully utilized, if projected in a reasonably distant future, if taken for what they really are, just plain probability, such extrapolations may well be extremely useful. In fact, their usefulness is recognized by many businesses which largely base their investment and long-range production policy on them and often obtain results of astonishing accuracy. Very refined techniques of forecasting sales on this basis have been developed. In some instances, researches on changes in population are so essential that they are considered as one of the main factors of production planning.† Such is the case of some public utilities, which give a careful and continuous attention to population growth in the territory in which they operate.

The Long Island Lighting Company, for instance, considers changes in population as the prime factor affecting company sales, and spends much time and effort in studying population trends. Its fore-

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* The reader who is not already familiar with the "growth curve" and its application to the growth of industrial production may find it beneficial to read Chapter XVI before the present one.

† For more details see National Industrial Conference Board *Studies in Business Policy* No. 25, "Forecasting Sales."

casting department's methods are described as follows in a report recently published: *

> Careful and continuous population studies are made of the areas served by the Long Island Lighting Company. These studies take into account the birth and death rates, the migration of people, new construction, and other similar factors. From these studies a trend of population is established and forecast. Regular reports are made by local managers on construction and applications for service. They also make reports for new industries. The reports are studied for possible effect on population-meter ratios.
>
> By applying the forecasted population-meter ratio to estimates of future population, the number of meters in use can be forecast.

Other kinds of businesses are affected not only by changes in the total population of a certain area, but also by changes in the composition of the population, its characteristics, habits, etc. The data on population trends are not always used to their full extent although they are available for many areas. Their availability should be better known by business. †

Recognizing the importance of population data as to growth, character, etc., a prominent business research organization, serving many industrial enterprises, recently advised its clients in the following terms:

> YOUR LONG-RANGE MARKET . . . With developments popping fast & urgently, it's sometimes hard to get away from the immediate grind for a look ahead. But many executives are taking time out to study some new

---

* *Ibid.*

† In addition to the well-known decennial United States Census of the Population, detailed and comprehensive data are available on the subject of the past, present, and probable future population of the United States. See especially:

National Resources Committee, *Population Statistics.*

W. Thompson and P. K. Whelpton, *Estimates of Future Population by States*, Washington, D.C., 1934.

P. K. Whelpton, *Forecasts of the Population of the U.S. 1945-1975*, Washington, D.C., 1947.

Department of Commerce, Bureau of the Census, *Current Population Reports*, such as:

Series P.25 # 1—July 9, 1947—Provisional estimates of the population 5 to 17 years old.

Series P.25 # 4—Oct. 12, 1947—Provisional estimates of the population of the U.S. by regions, divisions, and states.

Series P.20 # 2—Sept. 9, 1947—General characteristics of the civilian population of the U.S.

Series P.20 # 10—Feb. 6, 1948—Characteristics of single, married, widowed, and divorced persons.

Series P.20 # 12—Feb. 16, 1948—School enrollment of the civilian population.

Series P.50 # 4—Feb. 9, 1948—Comparative occupation statistics by sex for the United States.

market data . . . *population* figures which, in the last analysis, are the basis of all sales, especially if your sales policy is in any way geared to:

. . . Total population.
. . . The number of people in various age groups.
. . . The number & distribution of households.
. . . Types of families.

DO THESE CHANGES AFFECT YOU? . . . . There have been important shifts . . . Here is some of the more significant population information for sellers, just published in a special census report. . . .

1. *The baby boom hit its peak in 1947 . . . census estimates* 3,720,000. (The figure was only 2,360,000 in 1940.) Obviously, this means a huge increase in the market for goods for young people . . . now and in the future. For example, if you sell a product for 7-year-olds, your market will grow; in 1954 it will be about 60% larger than it is today.

2. *But the baby boom is slowing up* . . . (rate of marriages is dropping). A slump to 3,250,000—maybe even lower—is expected for this year.

3. *Shift from farm to city is continuing* . . . concentration of households in non-farm areas is growing—83% in '47 as compared to 80% in '40.

4. *Net growth in the number of households in the years* '40–47 was:
. . . In Northeastern states, about 12%.
. . . In North Central states, about 10%.
. . . In the West, about 25%.
. . . In the South, no significant change.

5. *The number of related persons living in one household is dropping*, from average 3.15% to about 3.07% for U.S. as a whole . . . Evidently, sons & daughters moving out to get married account for it; and that should mean great demand for all sorts of household merchandise . . . everything from pots & pans to furniture & rugs, appliances, etc.

Observation . . . The census is full of similar market information. It's impossible to do more than hint at the wealth of useful material . . . which you can select & apply in terms of your specific market interests. Get hold of a copy for yourself—write to Census Bureau, Dep't of Commerce, Washington, D.C., and ask for "Household Composition and Characteristics in 1947 for Urban and Rural Areas and Regions." It is series P-20, No. 11 . . . free of charge.

This illustrates strikingly the kind of statistical data concerning population characteristics which the businessman should be using. Such data, for instance, as the above-mentioned census estimates of a so-called baby boom peak in 1947, are of very general interest. They forecast an exceptional "wave" that will be felt for many years to come and should be taken in consideration by all kinds of businesses: by baby carriage manufacturers in the near future, coffin

manufacturers in a more distant one, life insurance companies, clothing manufacturers, etc., in between.

Independently from this exceptional "baby wave," it is a generally known fact that the United States population is aging.* It is estimated † that the proportion of individuals over 65 years of age, which was 6.8 percent of the total population in 1940, will be about 11 percent in 1975. This means an increase from 8,966,000 individuals over 65 years of age, in 1940, to approximately 17,000,000, in 1975.

The needs and wants of aged individuals are essentially different from those of younger people. Alert manufacturers will not fail to prepare for the increase of this special market, which will double in size during the next twenty-five years, according to this estimate.

At the same time the business community as a whole should not fail to give serious consideration to the trend of the total United States population. This trend develops since 1750 ‡ a pattern strikingly following that of a "growth curve," as shown by Figure 65.

Such a trend, by itself, will generally be of little direct use to the individual enterprise which is more interested in specific cases (population of a state, a town, relative composition of the groups, etc.). But it does provoke some serious thoughts concerning the general economic picture.

It is not pure coincidence that in the United States the great economic prosperity of the last hundred years is, in fact, associated with the impressive rate of population growth pictured by Figure 65. At the same time, it is a fact that the stimulation of the effective demand

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* See National Resources Committee, *The Problems of a Changing Population*, Washington, D.C., 1938.

† P. K. Whelpton, *Forecasts of the Population of the U.S. 1945–1975*, Washington, D.C., 1947.

‡ Population of the United States (in thousands) 1750–2000 (1750–1945 actual; 1950–2000 forecast under the assumption of medium fertility and mortality, no immigration. Source: National Resources Committee and P. K. Whelpton, *op. cit.*)

1750	1,207	1800	5,308	1900	75,995	2000	163,312
60	1,610	10	7,240	10	91,972		
70	2,205	20	9,638	20	105,711		
80	2,781	30	12,866	30	122,775		
90	3,929	40	17,069	40	131,669		
		50	23,260	45	139,621		
		60	31,502	50	145,460		
		70	39,904	60	153,375		
		80	50,262	70	159,847		
		90	63,056	80	163,877		
				90	164,585		

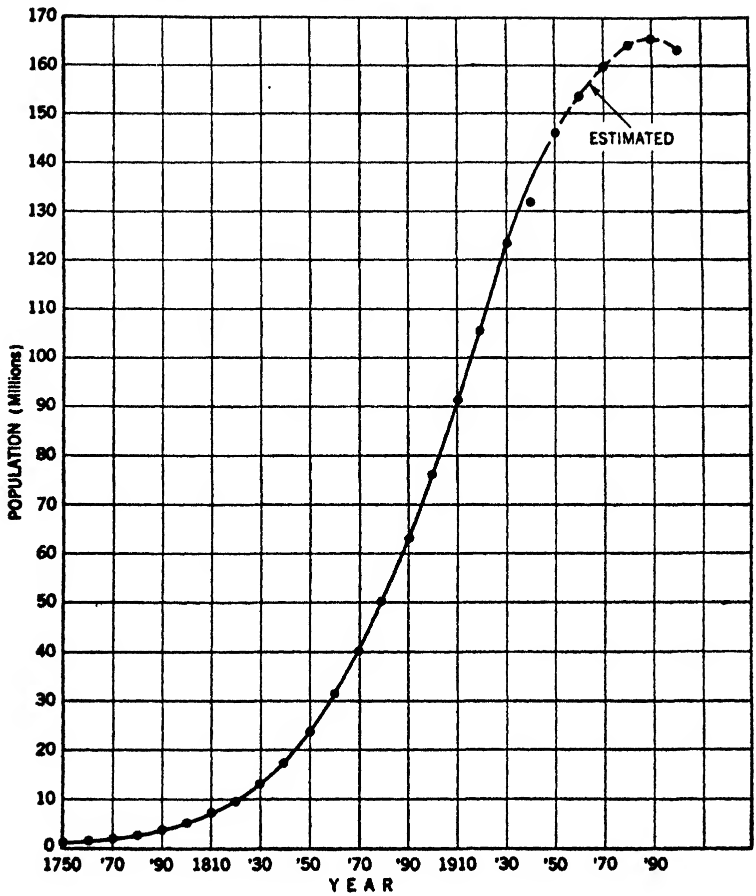

Figure 65. Curve of Population Growth in the U. S. A., 1750–2000

provided by an ever-expanding population cannot now be counted on to the same extent as before.

As already mentioned, the size of the population is only one factor of effective demand. If the income, the capital, the credit of a given population (i.e., its purchasing power) increase, the effective demand increases also. For all practical purpose the resulting stimulation is comparable, in its economic effects, to an increase of population.

Therefore, the fact that the United States population is not expected to increase any more at a rate comparable to the past century's one, does *not* mean a stagnating effective demand. But it does mean that the environment in which the economic process has been operating

up to now is undergoing a fundamental change. The need for adjusting the economic process to the new environment is therefore quite apparent. The numerical increase of a population is the result of long-range trends, not only of economical nature but also and even mainly of cultural, political, biological, ethnical, educational nature. It is a *fact* somehow imposed upon a nation. The experience of other countries and other civilizations shows that little if anything can be done to influence population growth trends except there be a drastic change in the environment.

As long as the growth rate was so beneficial in its effects that there was little or no need for stimulating otherwise the economic prosperity, it was normal and understandable that little attention be paid to the possibility of influencing other economic factors.

If and when conditions change fundamentally, as is today the case, the other factors become more and more important and needed. Could they not be more intelligently dealt with than seems to have been the case in the past?

An individual enterprise can do very little in the right direction. But the business community as a whole can and should take the lead. This book does not intend to do more than indicate some of the principal considerations which should be given to dealing intelligently with the problem of an approaching stability of population. There is an increasing necessity for a better comprehension of economic forces and for a more coordinate action by the business community as a whole, the reason being that the somehow "automatic" factor of population growth is losing its importance, thereby giving more weight to the other factors, such as population's income, capital, credit, which are definitely responsive to rational action.

The need for a more scientific treatment of economic problems and for a closer cooperation of individual enterprises begins to be recognized in academic and in business circles as well, and is stimulated by organizations of research, such as the Committee for Economic Development, for example. An authoritative representative of this committee expressed himself, some time ago, in a forceful manner on the subject, by saying:

> We all support and should support great technological research. But we have fallen short in economic research.
>
> For research in technology we have spent hundreds of millions of dollars by industry and more recently by government. Compared with that, pathetic amounts have been brought to the support of research that will help build a society to use that technology for the general welfare, to administer that technology wisely. The research going on in the princi-

> ples of administration, in the understanding of our economic and social environment and in the field of human relations is today tragically small.
>
> There is need for much more—and more effective—economic research. To be of the highest value, it has to be independent, skillful, and most of all, honest—honest in its search for objective findings, not developed to prove a point. . . .
>
> Usually some label of academic calm or ivied walls or ivory towers is put on those who work in universities. I sometimes think there are today more ivory towers in the business community than in the universities. Far too many businessmen have secluded themselves with their own groups without opening their minds to what is happening around, without appreciating the social and political and economic responsibilities of business leaders.*

By giving more attention to the general conditions, such, for instance, as the trend of total population growth, the business community as a whole would undoubtedly help itself in the long run. It would be in a better position to appreciate the growing importance, for the future economic prosperity, of the other factor of effective demand, namely, the purchasing power.

II. PURCHASING POWER

The power of a waterfall is determined by the volume of the water and by the height of the fall. In like manner the *effective demand* (as previously defined) is determined by the size of the population and its purchasing power.

The "size of population" factor, having been considered in the first part of this chapter, it remains now to discuss the other factor—its purchasing power.†

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* Remarks by Donald Kirk David, Dean, Graduate School of Business Administration, Harvard University, before the Board of Trustees, Committee for Economic Development, July 12, 1946.

† To illustrate the discussion, data will now be used, which, by necessity, are the ones available at the time this book is being written. It is obvious that any conclusions on such matters depend on the given data. They are valid only for a given period.

But situations change and, today, they change very rapidly. The purpose of this book being to help the reader at the time he reads it, an effort will be made to use today's situation only as basis for the discussion. Rather than formulae ready for use, general principles will be developed. To apply such principles to a future situation, the reader must, in turn, have the necessary data. With the purpose of helping him to find rapidly such data, the authors are, in this chapter, extensively quoting their sources, selected from publications easily available and regularly publishing their statistical information (such as the *Survey of Current Business*, the *Monthly Review of the Bureau of Labor Statistics*, the *Federal Reserve Bulletin*, etc.).

In the complex organization of modern economic life, the population's purchasing power is composed of various elements. A customer who wants to purchase given goods at the price for which they are actually offered may consider the following ways:

1. Buy them for *cash*, by using part of his *income*
2. Buy them for *cash*, by using part of his *capital* (dissaving)
3. Buy them for cash derived from *borrowed money* (consumer loan)
4. Buy them *on open account credit*
5. Buy them *on instalment.*

An accurate forecast of the customers' intentions and financial possibilities means the difference between failure and success in business. Past experience, knowledge of the market, and bankers' advice will help the businessman in this respect. But today, more than ever, because of the growing complexity of economic conditions, the businessman must be familiar with the whole problem of customers' purchasing power. The purpose of the following pages is precisely to discuss this problem by studying the three elements of purchasing power:

A. Consumer's income
B. Consumer's capital
C. Consumer's credit.

A. CONSUMER'S INCOME

The first approach to an investigation of the consumer's income is a study of the aggregate income earned by the whole nation, the national income.

1. National Income. The "national income" is defined as *"the aggregate earnings of labor and property which arise from the current production of goods and services by the nation's economy."* *

Table LIII shows the variations of the national income since 1929.†

* Definition from the *Supplement to Survey of Current Business,* United States Department of Commerce, July, 1947, "National Income and Product Statistics in the United States, 1929–46."

The factors to be used in the determination of the national income have been the subject of some controversy in the past. They are now authoritatively defined by the Department of Commerce (*Ibid.,* p. 8).

† Figures for the national income are published by the monthly *Survey of Current Business* (United States Department of Commerce) and reproduced by the monthly *Federal Reserve Bulletin,* issued by the Board of Governors of the Federal Reserve System. They are also reproduced by various private publications.

TABLE LIII

NATIONAL INCOME
(*Millions of Dollars*)

1929	87,355	1939	72,532
1930	75,003	1940	81,347
31	58,873	41	103,834
32	41,690	42	136,486
33	39,584	43	168,262
34	48,613	44	182,407
35	56,789	45	181,731
36	64,719	46	179,289
37	73,627	47	202,500 *
38	67,375	48	215,500 *

Source: *Survey of Current Business.*

* 1947 and 1948 data, subject to adjustments.

The above figures give a fair representation of the variations of the economic well-being of the nation as a whole, but they do not necessarily represent the variations in the customers' actual purchasing power in which the manufacturer is interested.

Some factors that are *not included* in the computation of the national income may actually increase the income received by each individual. Such factors are:

a. Net interest paid by Government
b. Government transfer payments
c. Business transfer payments.

Some other factors that *are* included in the computation of the national income may unduly inflate the actual income received by each individual. Such factors are:

a. Undistributed corporate profits
b. Corporate profits tax liability
c. Corporate inventory valuation adjustment
d. Contributions for social insurance
e. Excess of wage accruals over disbursements.

2. Personal Income. The computation of the personal income eliminates such distorting factors. The personal income is measured as *"the sum of wage and salary receipts, other labor income, proprietors and rental income, interest and dividends, and transfer payments."* *

* Supplement to *Survey of Current Business,* July, 1947. Reference is made to this text (page 8) for a more detailed discussion of the personal income and of the transfer payments.

From the point of view of the businessman, the *personal income* gives him a more realistic figure of the aggregate earnings of his customers than the *national income* does. But it still does not give him an accurate estimate of that part of their income which they can actually dispose of. They have to pay various taxes that have exactly the same effect on their purchasing power as a reduction in income.

3. *Disposable Income.* What is left of the personal income after such taxes have been deducted is called the "disposable income," which is defined as *"the income remaining to persons after deduction of personal tax and other payments to general government."* [a]

4. *Comparison.* Depending on the relative importance of the various factors which influence their components, there will be or will not be a substantial discrepancy between *national, personal,* and *disposable income.*

Table LIV illustrates how the situation may vary from year to year, according to circumstances. The years 1929, 1933, and 1945 have been selected because they are typical of extreme situations.

TABLE LIV

COMPARISON OF NATIONAL, PERSONAL AND DISPOSABLE INCOME

(*Billions of Dollars*)	1929	1933	1945
National income	87.4	39.6	181.7
Personal income	85.1	46.6	170.3
Disposable income	82.5	45.1	149.4

The year 1929 shows the relationship in a year of peace and prosperity. The difference between national and personal income, partly due to undistributed corporate profits, is moderate. The difference between personal and disposable income, representing the taxes paid, is equal to $2.6 billions or 2.9 percent of the national income.

The year 1933 is a year of economic depression. Due partly to an increase of government payments and partly to the distribution of $2.4 billions of corporate profits previously earned, the personal income is *higher* than the national income.

The year 1945 illustrates the situation in a year of high taxes. The difference between the personal and the disposable income reaches $20.9 billions or 11.5 percent of the national income as compared to 2.9 percent in 1929.

[a] *Ibid.*

Such comparisons show that the disposable rather than the personal or the national income should be used as an aid for determining the consumers' purchasing power.

5. *Disposable Income and Consumers' Expenditures.* The disposable income is only one of the factors to be considered in measuring purchasing power. Everyone knows that some of us do not spend all of our disposable income but save part of it, while others spend more than their disposable income by using part of their past savings or by borrowing money, for example.

However, experience shows that, for the population as a whole, there is a definite relationship between the sales volume of most of the consumer goods and the disposable income. Consumer expenditures, as the remark has often been made, are very sensitive to income changes.*

The reader realizes that such a remark can be of practical use only if a "quantitative" and not a "qualitative" analysis of the situation can be given. In other words, if the businessman is told that his sales do vary with consumer's income but not told how much, the relationship is of little help, if any at all. Numerous attempts have been made to analyze quantitatively such a relationship. But there are many obstacles. One of them is the instability of the yardstick, the dollar. If the goods sold are measured by the ton—as they often are—and the disposable income is measured in dollars and cents, intricate and always disputable adjustments are required to make the dollar 1945, for instance, comparable to the dollar 1939, or to the dollar 1932. (For a discussion of the variations of the yardstick-dollar, see the preceding chapter.)

One danger is to oversimplify the issue; another—and not a lesser one—is to overcomplicate it.

For instance, inspection gauges are usually manufactured under extremely small tolerance limits. The production of plows, however, would not be economically possible if the same limits were prescribed. No farmer would be able to pay the price. Besides no plow needs to be produced under such extremely small tolerance limits—it will do good plowing without it.

Similar considerations should be kept in mind when evaluating the relationship between disposable income and the sale of goods. Even

* See, among others: J. Frederic Dewhurst and Associates, *America's Needs and Resources*, New York, 1947, Chapter 5. Also: L. J. Paradiso, "How Can Business Analyze Its Markets," March, 1945, and "Retail Sales and Consumer Income," *Survey of Current Business*, October, 1948.

more so, if the purpose is actually to help business management in its task of sales and production planning. An attempt will be made here to find the best approach to the problem, in terms as simple as possible.

The method to be followed is, in many respects, similar to the one previously used for the construction of the profit and loss chart and of the break-even chart (see Chapter IV). At that time, the relationship studied was that of expenses to sales for a given business. We endeavored to determine what pattern, if any, was followed by such relationships. We actually found that normally such a pattern does exist in the form of a straight-line trend. We also found that under certain conditions it was possible to determine the trend of expense in relation to sales for a given business. Such a trend indicates the "normal" behavior of a sales-expense relationship. It can be used for control purposes by calling attention to any departure from the trend and for forecasting purposes, if and when extrapolation is justified.

One may well ask: Is there any functional relationship between *sales* (sales of a product or of a group of products, or even sales of a given business) and *disposable income* as there is a functional relationship between expense and sales? If so, the trend of such a relationship can be used for controlling and forecasting sales in relation to disposable income just as it has been found possible, within certain limits of accuracy, to control and forecast expenses in relation to sales.

While the sales of some goods do not seem to follow as distinct a pattern in relation to disposable income as do other goods, the sales of most consumer goods do follow a definite pattern in relation to disposable income, implying the existence of a functional relationship.*

This pattern for a period of years will now be shown for:

1. The total personal consumption expenditures
2. The personal consumption expenditures for a few important products.

The period chosen is 1929-1948, for which the following data are available.† (Table LV)

On the basis of these data, Figures 66, 67, 68, 69, and 70 have been

* See F. J. Dewhurst, *op. cit.*, Chapters 4 and 5, and Appendix 9. Also L. J. Paradiso, *op. cit.*

† The data prior to 1929 are not readily comparable to the ones now being published by the Department of Commerce, and could not be used in this study without tedious adjustments. (See Introduction to the National Income Supplement to *Survey of Current Business*, July, 1947.)

prepared. The annual disposable incomes are plotted as abscissa; the annual consumption expenditures are plotted as ordinates.

a. Total Personal Consumption Expenditures

Figure 66 shows the total personal consumption expenditures in relation to disposable income for the years 1929–1948. The graph clearly shows three periods.

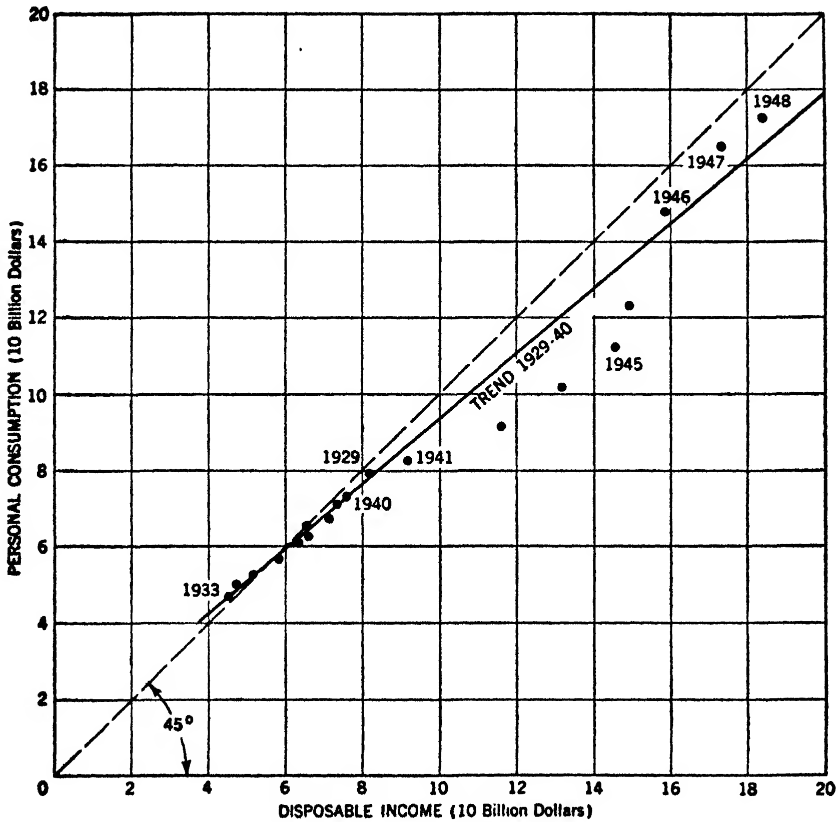

Figure 66. Personal Consumption in Relation to Disposable Income, U. S. A., 1929–1948

First Period: 1929–1940

These twelve years are the most interesting ones from the point of view of economic research because:

(1) They include twelve years of changing economic activity (depression period 1929–1933, postdepression New Deal period, mild recession of 1938, prewar activity).

TABLE LV

DISPOSABLE INCOME—DISPOSITION OF INCOME—
EXPENDITURES FOR SELECTED PRODUCTS
(*Millions of Dollars*)

	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
Disposable income	82,484	73,688	62,977	47,819	45,165	51,635	57,973	66,095	71,055	65,465
LESS Personal consumption expenditures	78,761	70,789	61,153	49,208	46,346	51,882	56,215	62,515	67,121	64,513
EQUALS Personal savings	3,723	2,899	1,824	−1,389	−1,181	−247	1,758	3,580	3,934	952
Food (consumer purchases)	17,575	16,147	13,223	10,149	10,291	12,908	14,634	16,788	18,172	17,335
Clothing (ex: standard military clothing)	11,006	9,564	8,106	5,963	5,354	6,472	6,919	7,546	7,951	7,862
Recreation	4,327	3,986	3,298	2,439	2,199	2,437	2,625	3,014	3,374	3,235
Household operation	10,509	9,378	8,264	6,675	6,396	7,107	7,604	8,660	9,340	8,732

TABLE LV (CONTINUED)

	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
Disposable income	70,167	75,743	92,015	116,197	131,617	145,574	149,430	159,176	173,577	184,100
LESS Personal consumption expenditures	67,466	72,052	82,255	90,835	101,626	111,401	122,830	147,363	164,755	172,300
EQUALS Personal savings	2,701	3,691	9,760	25,362	29,991	34,173	26,600	11,813	8,822	11,800
Food (consumer purchases)	17,724	19,123	22,426	27,776	31,725	34,728	38,347	47,463	53,790	*
Clothing (ex: standard military clothing)	8,277	8,737	10,273	12,426	14,952	16,300	18,366	21,603	22,411	*
Recreation	3,446	3,740	4,225	4,590	4,664	5,314	6,021	8,625	9,360	*
Household operation	9,461	10,292	11,724	12,235	12,559	13,453	14,824	18,646	21,973	*

Source: *Survey of Current Business.*

* Data not available.

(2) They exclude the war period and the war-created deep disturbances.

During these twelve years, the trend of the ratio of total personal consumption expenditures to disposable income clearly develops along a straight line, the equation of which is:

$$PC = \$7.5 \text{ billions} + 85\% \text{ DI}$$

where DI is the disposable income; and PC the total personal consumption expenditures.

The trend is the same for all twelve years. (We will see, in studying selected expenditures, that two distinct trends are observed for some of them during the same period, one for the years 1929–1933, years of depression, and one for the years 1934–1940, period of economic expansion.)

SECOND PERIOD: 1941–1945

These are the war years. It is a well-known fact that, during these years, involuntary spending restrictions and a high rate of saving accompanied limitations of civilian goods production.* It was to be expected that consumption expenditures should be *less* than indicated by their trend. It is exactly what Figure 66 shows.

THIRD PERIOD: 1946–1948

As production limitations were gradually withdrawn near the end of the war, consumer expenditures increased far more rapidly than consumer incomes. Many consumers started dissaving on a substantial scale.†

It was thus to be expected that consumption expenditures should be *more* than indicated by their former trend. Again, this is exactly what Figure 66 shows.

The difference between disposable income and total personal consumption expenditures is sometimes termed *personal savings*. Graphically, the personal saving for each year is measured by the difference of ordinate between the point figuring consumption expenditures and a 45° angle line similar to the one used for the profit and loss or the break-even chart.

Such a line has been drawn in Figure 66.

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* For a detailed study of the subject, see: "Survey of Consumer Finances," by Duncan Mc.C. Holthausen in *Federal Reserve Bulletin*, August, 1947, and August, 1948.

† *Ibid.*

b. Selected Consumption Expenditures

A few expenditures have been selected as especially representative. They are the consumption expenditures for food,* clothing,† and recreation and household operations.‡ The four graphs, reproduced in Figures 67, 68, 69, and 70, show a striking similarity with the graph for total expenditures of Figure 66. There are also three periods, which

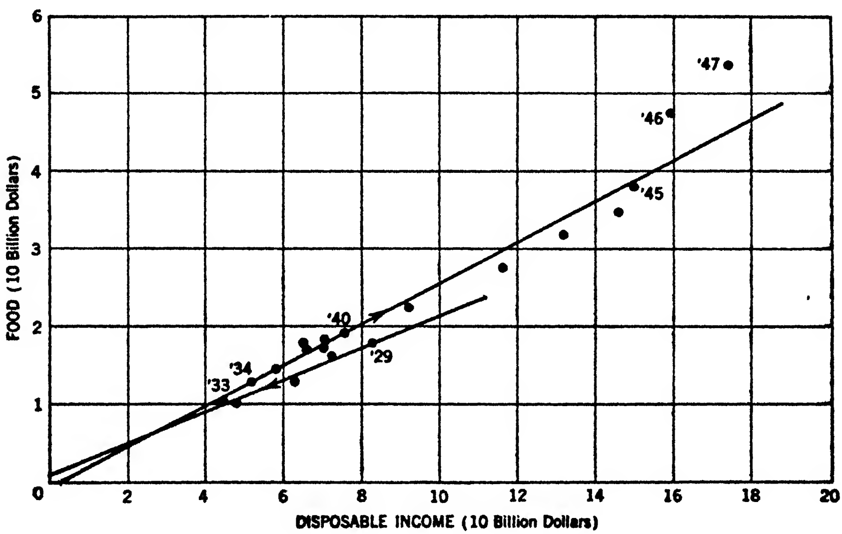

Figure 67. Food Consumption in Relation to Disposable Income, U. S. A., 1929–1947

are (with some slight discrepancies in 1945 and 1946, noticeable on the graphs):

First period	1929–1940
Second period	1941–1945
Third period	1946–1947 §

* Including: Food purchased for off-premise consumption and purchased meals and beverages. Excluding: Food produced and consumed on farms, food furnished government and commercial employees and withdrawn by non-farm proprietors.

† Excluding: Standard clothing issued to military personnel.

‡ On the average, over the years, about 50 percent of the expenditures reported as "household operations" are represented by expenditures for fuel, electricity, gas, water, and telephone. The other 50 percent include such expenditures as: furniture, electrical appliances, domestic service, fire insurance, etc.

§ Detailed data for a later year not yet available.

There are some differences in the details which will now be discussed.

Food Expenditures (Figure 67). The first period, 1929–1940, shows two trends, one for the recession years, 1929–1933, and one for the years of economic recovery, 1934–1940. It will be observed that the second trend is above the first one, corresponding to the well-known improvement of the food growers' economic situation.

The second and third periods, 1941–1945 and 1946–1947, do not need special comment. The graphs show that the behavior of food expenditures was similar to that of total consumption expenditures (see page 369).

The trend for food expenditures, as determined during the years 1934–1940, is expressed by the equation

$$F = \$ - 1 \text{ billion} + 26.5\% \text{ DI}$$

where DI is the disposable income and F the food expenditures.

Clothing Expenditures (Figure 68) and Recreation Expenditures (Figure 69). Their behavior appears similar to that of the food expenditures, with the qualification that the trend for the recovery years

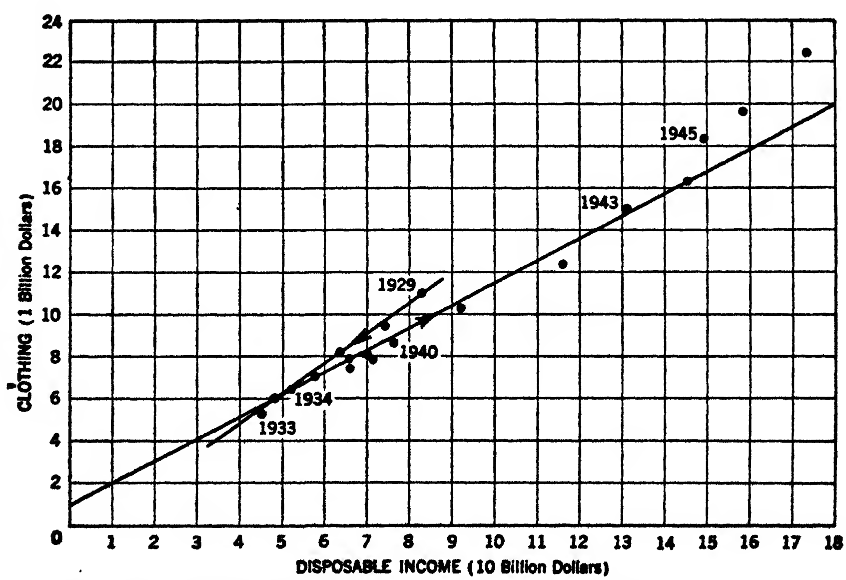

Figure 68. Clothing Consumption in Relation to Disposable Income, U. S. A., 1929–1947

1934–1940 is under the 1929–1933 trend while the opposite was true for food expenditures.

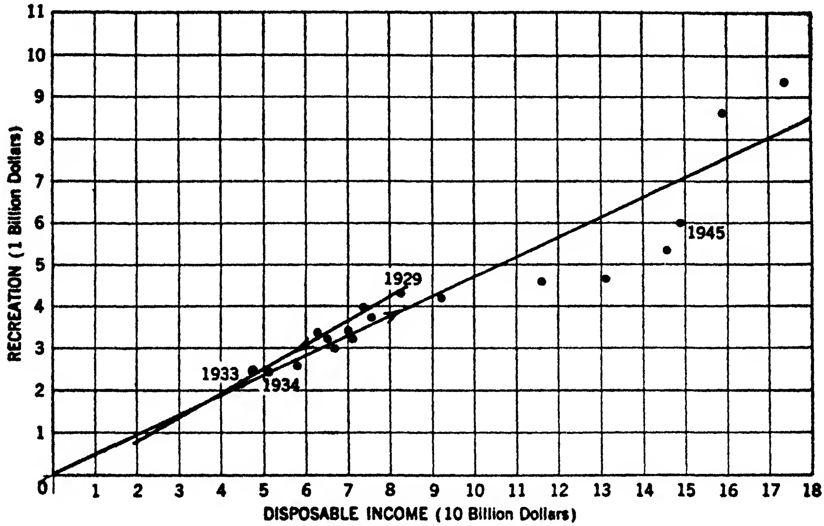

Figure 69. Expenditures for Recreation in Relation to Disposable Income, U. S. A., 1929–1947

The 1934–1940 trends can be expressed by the following equations: For the clothing expenditures:

$$\begin{aligned} C &= \$1 \text{ billion} + 10.6\% \text{ DI} \\ \text{where DI} &= \text{the disposable income, and} \\ C &= \text{the clothing expenditures} \end{aligned}$$

For the recreation expenditures:

$$R = 4.7\% \text{ DI}$$

where R represents the recreation expenditures

Household Operations (Figure 70). These expenditures show a greater stability than the other selected expenditures or the total consumption expenditures. This special stability is obviously due to the fact that a large percentage of the expenditures, classified as household operations, include goods and services sold at a Government-controlled price. (See Note ††, page 373.)

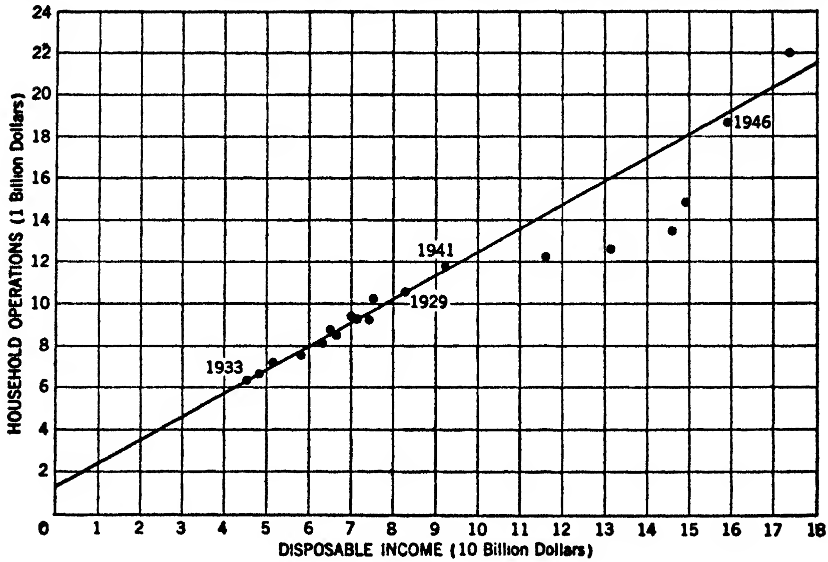

Figure 70. Expenditures for Household Operations in Relation to Disposable Income, U. S. A., 1929–1947

There is only one trend for the period 1929–1940, which is expressed by the equation:

$$H = \$1.3 \text{ billion} + 11.2\% \text{ DI}$$

where H represents household operation expenditures

c. Conclusions

This study of total personal consumption expenditures, and of a few selected consumption expenditures, in relation to disposable income over a period of about twenty years, enables us to draw a few positive and one negative conclusions.

Positive Conclusions:

(1) The striking straight-line trend or trends developed during the twelve years 1929–1940 shows the existence of a definite relationship of those expenditures to disposable income.

(2) This relationship, just as that of expense to sale within a business (see Chapter IV) is algebraically described by an equation of the type

$$Y = a + bX$$

where Y is the expenditure
X the disposable income
a and b are constants

(3) Some expenditures developed, during a period of economic recession, a trend distinct from the one developed during the years of economic recovery or expansion.

A negative conclusion can also be drawn, namely, that the departure from the trend during the war and postwar periods (1941–1945 and 1946–1948) is accounted for and does not disprove the existence of such a trend.

At the time this book is being written, no later data are available. It is left to the reader of a few years from now to plot the data of the years to come. The authors are not in a position to forecast whether such data will or will not show a continuation of the previous trends. But, barring an unforeseen renewal of an economic upheaval such as the one just witnessed during the war and the postwar period, the suggestion is ventured that the reader of the future will be able to determine a definite trend of relationship.

d. Practical Applications

An Example: The American Tobacco Company

The reader who has attentively followed the discussion related to the profit and loss chart, the break-even chart, and their practical applications (Chapters IV, VI, and VII), is now fully familiar with the various uses of such a pattern of relationship.

Just as the existence of a definite trend of expense to sales within a business has been found useful for analysis, controlling, or forecasting purposes, so the trend of consumption expenditures to disposable income can be used for similar purposes in the study of either the whole economic situation, or a given market, or the sales performances of a single business.

The practical applications of such a trend are so numerous that they cannot be described in detail within the limits of this book. They all derive from the fact that such a trend provides a yardstick with which it is possible to measure an actual performance or to estimate the probability of a future one. An example will illustrate.

A few years ago, a group of stockholders brought a suit against the management of the American Tobacco Company. They contended that some bonuses received by the management were unlawful. One of the arguments used by the management for its defense was that it had obtained a spectacular increase in sales. The stockholders' answer was that the increase in sales was due to an increase in tobacco consumption, not to management's ability.

As far as the authors know, neither side in the dispute used a truly scientific method to establish its claim.* The case should have been scientifically decided in the following manner.

Let us consider † the period 1934–1947. Table LVI gives the sales record of the American Tobacco Company for these years.

TABLE LVI

SALES OF THE AMERICAN TOBACCO COMPANY *

(Millions of Dollars)

1934	222.64	1941	336.93
1935	220.26	1942	422.15
1936	232.96	1943	529.42
1937	242.64	1944	533.37
1938	253.09	1945	557.57
1939	262.41	1946	764.16
1940	285.75	1947	819.63

* Source: Annual Reports to the Stockholders.

At first sight, such results are obviously impressive. In 13 years, sales increased by $597 millions, almost 270 percent. But, how do they compare with the development of the national market?

For the same period, 1934–1947, consumption expenditures for tobacco products and smoking supplies were as given in Table LVII.

TABLE LVII

CONSUMPTION EXPENDITURES FOR TOBACCO PRODUCTS AND SMOKING SUPPLIES *

(Millions of Dollars)

1934	1,370	1941	2,073
1935	1,438	1942	2,300
1936	1,540	1943	2,509
1937	1,679	1944	2,509
1938	1,703	1945	2,869
1939	1,773	1946	3,411
1940	1,875	1947	3,880

* Source: *Survey of Current Business.*

These expenditures are plotted in Figure 71 in relation to disposable income. It is seen that the increase in total sales of tobacco followed a

* Extracts of the briefs presented to the court have been published by the magazine *Your Investment* (January, 1940, and July, 1941).

† The lawsuit involved only the period 1934-1939, but it seems of interest to the reader to extend the study. The sales data of the American Tobacco Company prior to 1934 have not been made public, so that no discussion can be made of the previous period.

definite trend, to which it is now possible to compare the trend of the sales of the American Tobacco Company. Such a comparison could be made directly on a graph such as that in Figure 71, but the scale of the chart is such that it would be difficult reading.

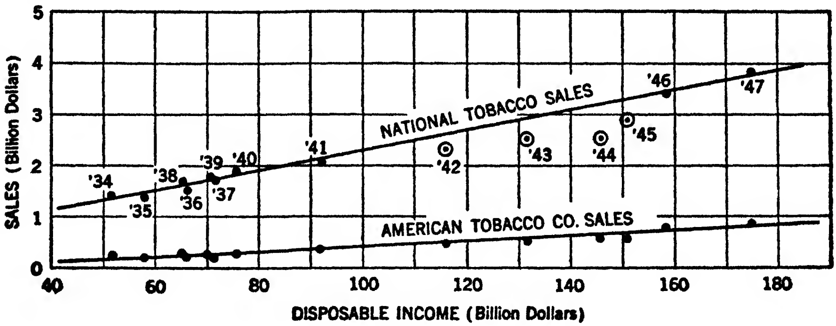

Figure 71. American Tobacco Co. Sales and National Sales of Tobacco

The reader will encounter the same kind of difficulty every time he tries to compare, on the same chart, the sales of a given corporation with total national sales in relation to disposable income. The reason is that the sales of a given corporation are normally insignificant when studied directly in relation to disposable income which runs into hundreds of millions of dollars. The way out of the difficulty is to study first the total national sales in relation to disposable income, as was done in Figure 71, and then study a given corporation's sales in relation to total national sales of the product under consideration, thereby eliminating the relation to disposable income.

This will now be done in Figure 72 by plotting American Tobacco Sales in relation to *total national tobacco sales.* The figures being lower than the ones for disposable income, the scale can be larger. Figure 72 shows that, in 1934, American Tobacco sales were $222.64 millions or 16.2 percent of the total market, which was $1,370 millions at that time. If the American Tobacco Company had just maintained its position, its share in 1947 would still have been 16.2 percent of the total market ($3,800) or $627 millions. Figure 72 shows the trend that *would* have been followed if the sales of the American Tobacco Company, after 1934, had remained at the level of 16.2 percent of total national tobacco sales. On the graph, this trend is called the "16.2 percent control line."

A comparison between the actual trend and the control line will now give us an immediate answer to the question: Was the increase

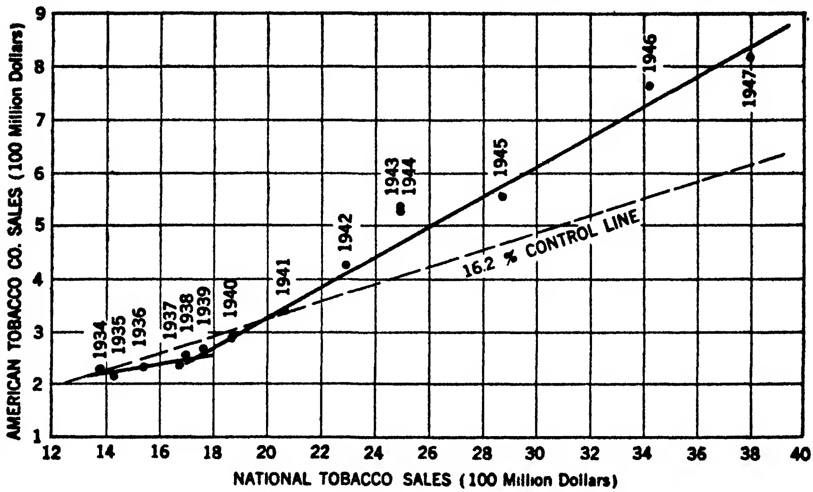

Figure 72. The Relation of Sales by the American Tobacco Co. to National Sales of Tobacco, U. S. A., 1934–1947

in sales shown by the company the result of its sales policy or of an increase in national consumption? Figure 72 shows that from 1934 to 1937, while the company's sales increased from $222.64 millions to $242.64 millions, it actually lost some of its share of the market. Starting in 1938, on the contrary, it took more and more of the market. However, it was not before 1941 that the company regained its 1934 share of the total market. (In Figure 72, this is shown by the meeting of the actual trend line with the "16.2 percent control line.")

If we want to measure year by year the result of the sales policy as compared to the general trend, we can proceed as follows:

(1) Determine the yearly percentage of American Tobacco Company sales as compared to total tobacco sales. We find the following percentages:

TABLE LVIII

AMERICAN TOBACCO COMPANY
SALES IN PERCENT OF TOTAL TOBACCO SALES

1934	16.2 percent	1941	16.2 percent
1935	15.3 "	1942	18.3 "
1936	15.0 "	1943	21.1 "
1937	14.4 "	1944	21.2 "
1938	14.9 "	1945	19.4 "
1939	14.8 "	1946	22.4 "
1940	15.2 "	1947	21.6 "

(2) Then represent graphically, year after year, the American Tobacco Company's share of the market (in percent of the total market). This is done in Figure 73.

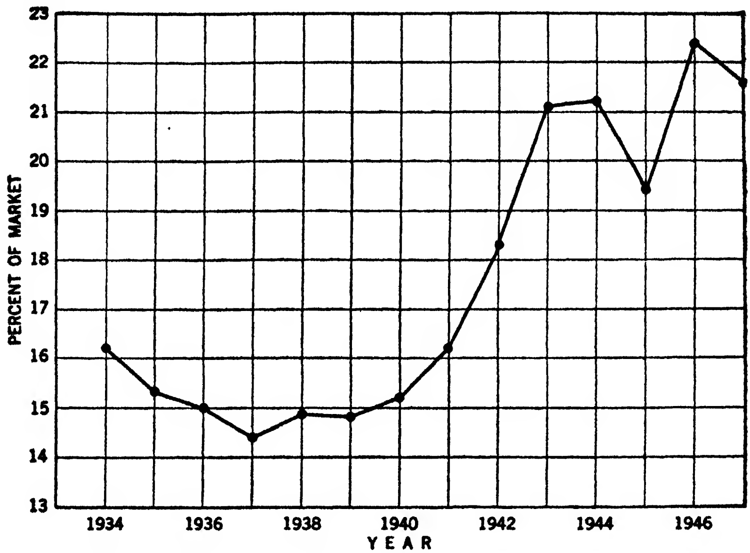

Figure 73. The American Tobacco Company's Share of the U. S. Tobacco Market, 1934–1947

We note:

(a) From 1934 to January 1, 1938, a descending trend
(b) After 1938, an ascending trend, first slowly ascending, then increasing its slope.

Such an analysis would give a scientific basis to a decision rendered on the disputed point. It shows that the stockholders' contention was justified for the period 1934–1938. After 1938, management made an obvious effort to improve its performance. By 1941, it had regained the ground previously lost, and after 1941 it performed remarkably well, as far as the sales figures are concerned.

The mere reading of the company's profit and loss statement does not reveal such facts.

It is interesting to note that 1938, which, according to this analysis, was a turning point in the company's life, was precisely the year during which the board appointed a new vice president in charge of advertising. His performance, later on, was highly praised in a letter of the president to the stockholders (February 1, 1940).

6. Income Brackets–Available Income

a. General Remarks. The whole previous analysis is based on the notion of *aggregate income.* Its usefulness is established by the existence of a definite trend of relationship of consumption expenditures to this aggregate income. But the limitations of this analysis are apparent, too. They result from the fact that the aggregate income is an aggregate of the incomes of widely different income groups, large, medium, and small.

Such a consideration is of little importance for the selling of a product like tobacco, for example. The market of the American Tobacco Company, just discussed, includes high-income, middle-income, and low-income customers as well. Very few people are so poor that they cannot afford to purchase cigarettes, and very rich people will also buy standard tobacco products.* The same is true for a few other products, such as bread or soft beverages, for instance.

For many products, however, and even for most of them, the manufacturer should be familiar with a too-little-known kind of income, which could be designated as the *available income.*

A producer seeking a market is interested only in those customers who have incomes which are available for the purchase of his goods. Thus far, we have considered the income from an *objective* point of view. The national income, the personal income, the disposable income are objective. They are the same for all manufacturers, and for the whole population under consideration (the nation, the state, or any other geographical unit). The available income is the income that is *available to given individuals or families for the purchase of a given product.* This is a subjective notion. An example will illustrate.

Two families, A and B, have respective incomes of $25,000 and $2,500. Family B has obviously no income available for the purchase of a $2,000 car. But both families have some money available for the purchase of a five-cent bottle of a soft beverage. The manufacturer of $2,000 cars must know how many families have an income available for the purchase of his production, so that he can know how wide his potential market is. Obviously, the study of the available income is a very complex one but it is a necessary one. As the available income is a subjective notion, a special study is required for each product. This book can only outline a suggested approach to the problem. The

* Low-income customers, however, may ration themselves, while high-income customers will not smoke indefinitely. Even for such products, therefore, a too great dispersion of incomes tends to reduce consumption.

first step is to become familiar with the distribution of income among the population.

b. Income Brackets. The "income brackets" or the distribution of income in the United States, according to the size of individual or family income, has been carefully studied during the last few decades. The various studies made at a few years' intervals (before, during, and after World War II) are based on statistical samplings. They have been conducted by somewhat different methods, but the results obtained reveal the same general pattern of distribution. They should thus be considered as confirming each other.*

TABLE LIX

DISTRIBUTION OF SPENDING UNITS * AND MONEY INCOME RECEIVED BY INCOME GROUPS–1947

(Percent)

Annual Money Income before Taxes	Spending Units		Total Money Income	
		Cumulative		Cumulative
Under $1,000	14%	14%	2%	2%
$1,000-$1,999	22%	36%	10%	12%
$2,000-$2,999	23%	59%	17%	29%
$3,000-$3,999	17%	76%	18%	47%
$4,000-$4,999	10%	86%	13%	60%
$5,000-$7,499	9%	95%	16%	76%
$7,500 and over	5%	100%	24%	100%
All income groups	100%		100%	
Median income †	$2,530			

* The *spending unit* is defined as "all persons living in the same dwelling and belonging to the same family who pool their income to meet their major expenses."
† The median amount is that of the middle spending unit when all units are ranked by size of income.

We will more specifically describe the latest available survey—that conducted by the Federal Reserve Board in 1948.

* See:
For the period 1935-36: National Resources Committee, *The Structure of the American Economy*, Part, I, pages 6, 9, 10.
For the year 1941: United States Bureau of Labor Statistics, *Bulletin #723 and 724*, United States Bureau of Agriculture, *Miscellaneous Bulletin #520*.
For a forecast of the postwar period: *Family Incomes and Postwar Markets*, by the Crowell-Collier Publishing Company, May, 1944.
For the year 1945: United States Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P.60 #2—"Consumer Income."
For the years 1945, 1946, and 1947: *Federal Reserve Bulletin*, June, 1948.
For a forecast of the year 1950: J. F. Dewhurst and Associates, *America's Needs and Resources*, New York, 1947, Table 21, page 65.

Table LIX gives the result of this survey, as far as the distribution of income for the year 1947 is concerned.*

If the spending units are ranked by size, their share of total income is shown by Table LX.

TABLE LX

SHARE OF TOTAL MONEY INCOME RECEIVED BY EACH TENTH OF THE NATION'S SPENDING UNITS, WHEN RANKED BY SIZE OF INCOME (1947)

Spending Units Ranked According to Size of Income	By Each Tenth	Cumulative	Income of Smallest Income Receiver in Group
Highest tenth	33%	33%	$5,700
Second	15%	48%	4,200
Third	12%	60%	3,500
Fourth	10%	70%	3,000
Fifth	9%	79%	2,550
Sixth	7%	86%	2,100
Seventh	6%	92%	1,700
Eighth	4%	96%	1,200
Ninth	3%	99%	750
Lowest tenth	1%	100%	0
	100%		

Source: *Federal Reserve Bulletin.*

For a clearer picture of the whole situation, a graphic representation will be found helpful. Figure 74 gives such a graphic representation of the income distribution in the form of a "Lorenz Curve." Figure 75 shows the income distribution in terms of annual money incomes.

This income distribution commands the selling price of products intended for mass consumption by the whole population, such, for instance, as most of the food products or the goods of current consumption sold in the popular ten-cent stores. Their selling price—and therefore their quality—must be adapted to the possibilities of a group of customers (the nation as a whole) whose median income is $2,530.

At the same time, the fact that almost one half of the national income is earned by one fifth of the population gives to this one fifth (the so-called "upper two tenths," earning more than $4,200) a very substantial economic weight. This accounts for the fact that a large

* *Federal Reserve Bulletin,* June, 1948. Data based on interviews in January–March, 1948.

part of the production of consumption goods (cars, radios, household appliances, etc.) is sold at a price that puts it obviously out of reach of the median income consumer.*

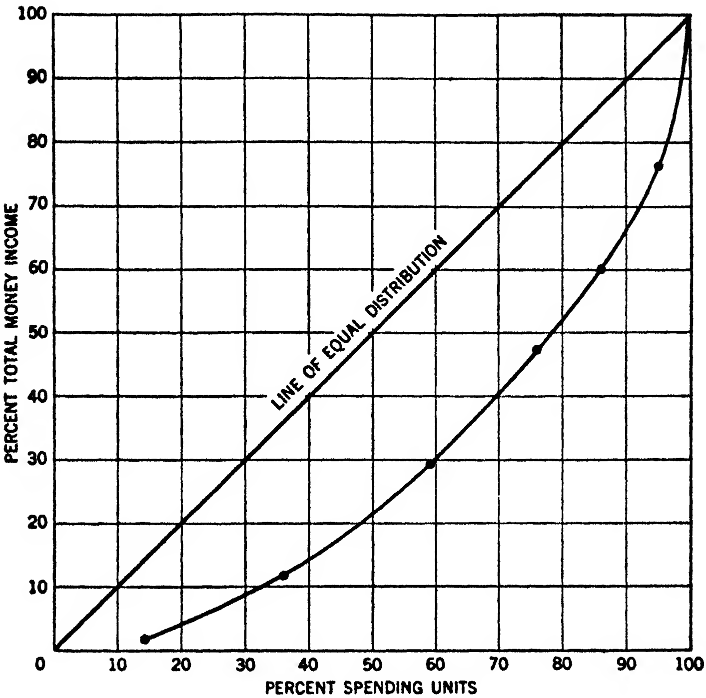

Figure 74. The Lorenz Curve of Income Distribution, U. S. A., 1947

It is sometimes difficult—but it is always vital—for a manufacturer to know in which income brackets his customers find themselves. Sometimes he will have to make his own survey, either directly or through specialized private organizations. Often he will find the required information in the surveys that are made and published by various public agencies. Such will be the case if he is in a position to know some definite characteristics of most of his customers.

The United States Bureau of the Census, for instance, recently published a detailed study of consumer income, and of its variation ac-

* Unless the purchase is financed by savings or credits, as will be shown later in this chapter.

cording to ages, family, or social status, major occupation and major industry groups, tenure, etc.*

The Federal Reserve Board made a survey of the distribution of spending units income by occupational groups, the results of which are given in Table LXI.

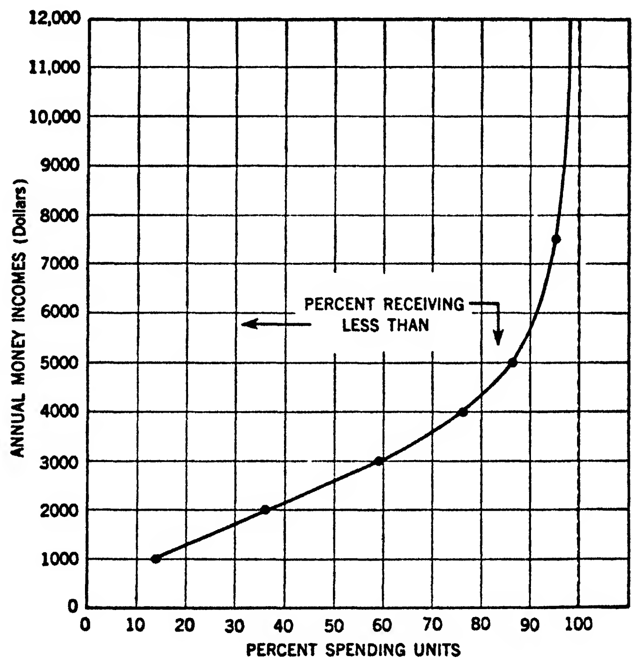

Figure 75. Income Distribution by Spending Units, U. S. A., 1947

The income distribution for farm operators is not closely comparable with the distribution for other groups because of the large amount of non-money income that farmers produce for their own consumption.

Such a survey shows, for instance, that a manufacturer producing for customers engaged in managerial activities may expect them to have a $4,500 median income, while if his production is intended for unskilled workers, he cannot count upon a median income higher than

* United States Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P.60 #2, "Consumer Income." See also Series P.60 #4, "Income of Families and Persons in Washington, D. C."

TABLE LXI

DISTRIBUTION OF SPENDING UNITS WITHIN DIFFERENT OCCUPATIONAL GROUPS, BY SIZE OF INCOME, 1947

(Percent)

Annual Money Income before Taxes	Professional	Managerial and Self-employed	Skilled and Semi-skilled	Clerical and Sales Personnel	Unskilled	Farm Operators
Under $1,000	5	4	3	6	18	34
$1,000-1,999	7	12	17	21	39	27
$2,000-2,999	15	14	30	25	29	18
$3,000-3,999	23	13	26	22	10	7
$4,000-4,999	10	12	15	11	4	6
$5,000-7,499	21	23	9	11	—	6
$7,500 and over	19	22	—	4	—	2
All Income Groups	100	100	100	100	100	100
Median Income	$4,000	$4,500	$3,000	$2,900	$1,750	$1,500

Source: *Federal Reserve Bulletin.*

$1,750. Such figures compare with the general median income of $2,530 previously indicated.*

c. Available Income. After the manufacturer has obtained a reasonably accurate estimate of his customers' income, he will then try to determine with reasonable accuracy their *available income as far as his products are concerned.*

As already emphasized, the available income is a subjective evaluation. A family of four, living in a large city, with an annual income of $2,000, has certainly a portion of its income available for bread and a certain amount of clothing but, obviously, no available income for a new car, a washing machine, or an expensive radio.

The available income of this family, in regard to the purchase of bread or of a certain amount of clothing, is *not* the same as the available income of the *same family* in regard to the purchase of a car, a washing machine, or an expensive radio.

This is precisely what makes it difficult to determine the available income of a given group of customers for a given product. All the same, a fair estimate of his customers' available income is necessary to the businessman. In fact, he would not stay in business if he was not able to make such a fair estimate.

* See Table LIX, page 383.

Many businesses base their market forecasts on feelings, rule of thumb, and hearsay. The main reason is that, until recently, they had no way of proceeding on a more scientific basis. The necessary information was just not available. The technique of the sample survey now in use to obtain information on consumer finances, for instance, is a development of relatively recent years.* It is normal that all businessmen are not yet aware of the exceptional opportunity for information offered by such new techniques. However, it is possible, today, in the United States, as probably in no other country in the world, for a businessman to gain a reasonable knowledge of his customers' income. This is the first step toward the determination of their *available income in regard to a given product.* The second step requires a reasonable knowledge of their expense budget.

Although the information published on this subject may not be as complete as that published concerning consumers' income, it can be extremely useful in many cases. Also, it is probable that the techniques now in use will be improved and that business of the future will make an increasing use of the statistical information on hand. The student in managerial economics will certainly profit greatly by becoming familiar with the various studies and surveys of the subject made in the past or being periodically conducted. He should also give serious attention to future developments in the field, which developments can be safely predicted.

Among the comprehensive studies and surveys now available, the following can be mentioned:

(1) The very comprehensive "Study of the Consumer Expenditures" in the United States, made in 1935–1936 by National Resources Committee.† This study, although made in the prewar years, still yields a real wealth of information. It is a basic document on the question.

(2) The yearly "Survey of Consumer Finances" by the Board of Governors of the Federal Reserve System. This survey was started in 1945, and it is hoped that it will be continued. The results have been published in the June, July, and August issues of the *Federal Reserve*

* See: "Explanation of the Sampling Method" (*survey of consumer finances*) in *Federal Reserve Bulletin,* June, 1947; Churchman, Ackoff and Wax, *Measurement of Consumer Interest,* University of Pennsylvania Press, 1947; and also: United States Bureau of the Census' monograph, "A Chapter in Population Sampling," Washington, D. C., 1948.

† See also, National Resources Committee, *The Structure of the American Economy,* Part I (1939), page 6; and Churchman, Ackoff and Wax, *op. cit.*

Bulletin of 1946, 1947, and 1948. In addition to the part devoted to the consumer income, which has been largely used in the previous discussion, this survey gives detailed and reliable information concerning consumers' expenditures and buying intentions.

(3) The survey "How Families Use Their Incomes" by the United States Department of Agriculture, Washington, D.C., 1948.

(4) Scientific studies of the family budget, such as the "City Worker's Family Budget," published by the United States Department of Labor in 1947 and 1948.* According to this study, the total of the city worker's family budget for four persons in June, 1947, ranged from $3,004 in New Orleans to $3,458 in Washington, D.C., the lowest and the highest cost cities among the 34 surveyed by the Bureau of Labor Statistics. This estimate is to be compared with the median income of spending units within different occupational groups for the same year 1947, $3,000 for skilled or semiskilled; and $1,750 for unskilled workers (see above Table LXI). It is also interesting to compare, for instance, this figure of $3,458 for the family budget in Washington, D.C., with the recently published "Income of Families and Persons in Washington, D.C., 1947." † Such a comparison shows that in Washington, D.C., 38.8 percent of the families had in 1947 an income of less than $3,499. This means that almost 40 percent of the families in Washington, D.C., could not live according to the minimum standard established by the Department of Labor.‡

This standard is based on an estimate of a family budget, which is defined as follows by the United States Department of Labor, Bureau of Statistics:

". . . a list of goods and services that, according to the prevailing standards of the community, are considered essential. . . . The budget level described here is at a point . . . below which deficiencies exist in one or more aspects of family consumption." (See *Monthly Labor Review*, February, 1948, page 138.)

B. CONSUMER'S CAPITAL

If a study of the customer's available income for a given product reveals that there is not a sufficient available income to pay its price,

* United States Department of Labor, Bureau of Statistics, *Monthly Labor Review*, February, 1948.

† United States Department of Commerce, Bureau of the Census, P.60 # 4; September 24, 1948.

‡ The proportion is slightly reduced if one considers white families only. About 30 percent of the white families in Washington, D. C., have an income that does *not* enable them to live up to the minimum standard established by the Department of Labor.

the manufacturer should endeavor to know if he has a chance to be paid by the customer's capital.

In fact, dissaving is a current procedure today for a large part of the population *—even for the purchase of non-durable goods, that should, in a healthy economy, be paid for from current income. It has been estimated that more than one fourth of all spending units dissaved heavily during the year 1947 (33 percent of all spending units reported a decrease in liquid assets holding).

The manufacturer who counts upon his customers' savings for the financing of their purchases should be aware of the distribution of such savings according to their size and among the various groups of the population. The following tables (Tables LXII, LXIII, and LXIV) give him useful indications in this respect. (Source: *Federal Reserve Bulletin,* July, 1948.) †

TABLE LXII

DISTRIBUTION OF SPENDING UNITS BY SIZE OF LIQUID ASSET HOLDINGS

(Percent—1948)

Amount of Liquid Assets Held		Cumulative
None	27%	27%
$1 - 199	15	42
$ 200- 499	13	55
500- 999	12	67
1,000-1,999	12	79
2,000-2,999	6	85
3,000-4,999	6	91
5,000-9,999	5	96
10,000 and over	4	100%
	100%	

Median holding of those with assets—$820

Table LXII reveals that more than a fourth of the spending units have no liquid assets at all; more than half, less than $500 liquid assets; and more than three fourths, less than $2,000. Table LXIII shows that more than half of the liquid assets are held by the spending units ranked in the upper two-tenths income brackets. Table LXIV's median asset holdings should be compared to the table giving

* See *Federal Reserve Bulletin,* August, 1948, "Consumer Saving and the Allocation of Disposable Income."

† "Liquid Assets" includes U. S. Government bonds, checking and savings accounts; excludes currency holdings.

TABLE LXIII

PROPORTION OF LIQUID ASSETS HELD BY EACH TENTH OF THE NATION'S SPENDING UNITS, WHEN RANKED BY SIZE OF INCOME

(Percent—1948)

	By Each Tenth	Cumulative
Highest tenth	43%	43%
Second	14	57
Third	8	65
Fourth	7	72
Fifth	5	77
Sixth	6	83
Seventh	4	87
Eighth	4	91
Ninth	4	95
Lowest tenth	5	100%
	100%	

TABLE LXIV

SIZE OF LIQUID ASSET HOLDINGS WITHIN DIFFERENT OCCUPATIONAL GROUPS

(Percent—1948)

Amounts of Liquid Assets Held	Profes-sional	Mana-gerial and Self-employed	Skilled and Semi-skilled	Clerical and Sales Personnel	Unskilled	Retired
None	6	11	27	17	53	38
$1-499	23	21	34	32	26	17
$500-1,999	28	26	23	31	15	19
$2,000-4,999	24	18	12	14	5	10
$5,000 and over	19	24	4	6	1	16
	100	100	100	100	100	100
Median asset holdings	$1,350	$1,400	$250	$500	0	*

* Data not available.

the median income within different occupational groups (see Table LXI, page 387).

C. CONSUMER'S CREDIT

The previous analysis of consumer's income (national income, personal income, disposable income, available income) and of consumer's capital clearly shows that:

1. A high proportion of consumers have an income that is just sufficient or sometimes not sufficient for the payment of expenses necessary for an adequate standard of living.

2. The postwar dissaving by many spending units has weakened their liquid asset holdings.

3. The consumers whose incomes are such that it leaves them little or no available income for non-essential purposes are precisely those whose liquid assets are non-existent or not significant.

This situation is partly due to the difficulties of postwar adjustment and partly to inflation (see Chapter XIV). The conclusion to be drawn is that, as things are today, consumer credit is a necessity for the consumer, and for the producer as well, if the former is to get the goods and services he needs and the latter to attain the minimum level of sales under which he cannot break even.

At the same time, it should be fully realized that extensive consumer credits are a very serious factor in inflation. They are also a potential danger for the future if consumers' purchasing power is not finally adapted to consumers' purchases, as was shown by the 1929 experience of excessive consumer credits.

The difficulty in solving such a dilemma explains why there has been lately so much controversy and uncertainty about consumers' credit. The regulation which, during the war, severely restricted consumer credits (so-called Regulation W) ended soon after the war. It was reinstated in a milder form in the summer of 1948, but it is to be expected that future regulation will be needed to control a potentially dangerous situation.

The danger of the situation is not so much due to the increase in total amount of customer credits as it is due to the prevailing general conditions. In fact, consumer credits, if expressed in terms of percent of disposable income, have decreased rather than increased, as compared to the prewar situation.*

But other factors, which did not exist in the past, or did not exist to the same extent, create a disquieting situation. Among them are:

* The remark was made by A. A. Friedrich in the March, 1948, issue of *Banking*. He pointed out that total consumer credit, expressed in percent of disposable income, varied as follows during the last twenty years (selected years).

1929	9.2%
1933	8.6%
1939	11.0%
1941	10.7%
1946	6.0%
1947	7.6%

1. The inflation, which was studied in a previous chapter (Chapter XIV), and the consequences of which are being aggravated by consumer credits.

2. The high cost of living. It has caused a great number of consumers to use consumer credit for financing the purchase of non-durable goods, thereby creating an abnormal and unhealthy economic situation.

3. The fact revealed by a recent survey of the University of Michigan, that only half as many families were buying on credit in 1948 as in 1941. This seems to indicate that a large proportion of consumers are borrowing more than they will ever be able to repay.

The danger of excessive consumer credits was recently stressed as follows by R. M. Evans, a member of the Board of Governors of the Federal Reserve System, in a statement before the House Banking and Currency Committee.*

"Because more purchasing power is being added to a supply of funds already excessive in relation to available goods, expansion of instalment credit under present conditions is of an inflationary character irrespective of its relative level as compared, for example, with national income. While credit outstanding now amounts to no more than 3.9 percent of annual disposable income in the United States, as compared with a range of 5.5 percent to 7.1 percent in the years just preceding the war—the highest levels on record—conditions today are much different. In the year 1940, for example, when the percentage was at its peak, average unemployment was 14.5 percent of the total labor force, according to the Bureau of Census estimates, as compared with 3.5 percent in 1947. In other words, there is no slack today. More credit cannot call forth more goods—it can only add to the upward pressure on prices."

At the same time, the fact that in 1947, credit sales (charge account and installment) accounted for more than one fourth of total retail sales,† shows that, as things are today, business cannot exist without some sort of consumer credit, barring the possibility of extensive Government purchases for public works or re-armament purposes. This only confirms the impression gained by a study of the average consumer's income and capital.

From the point of view of business management, this means the necessity of considering a relatively liberal credit policy while at the same time realizing its possible dangers. Conservative managements endeavor to solve the dilemma by transferring their risk to a specialized

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* On August 2, 1948. Reprinted in *Federal Reserve Bulletin,* August, 1948.
† *Federal Reserve Bulletin,* July, 1948.

organization, even at a substantial cost. In fact, many businesses prefer to leave the financing of their installment sales to specialized companies, such as the sales finance company.

The charge account, this other form of consumer credit, is usually a risk of the business itself. Many businesses, however, do transfer the financial risk involved to specialized agencies by taking credit insurance. This method regains, periodically, its popularity, and will probably be looked on with more and more favor by business if the present uncertainty should increase.

Credit insurance is a form of insurance that covers accounts receivable. More widespread in textiles and apparel than in other industries, such protection is available to manufacturers, wholesalers, and jobbers in almost every field.

However, it is by necessity restricted to businesses whose loss record is fairly normal. If debt losses are exceptionally low, it is not worth paying the premium; if they are exceptionally high, the insurance company may well reject the application. Losses are never covered in their entirety. When an account fails, the insurance company will normally deduct a certain percentage from the unpaid purchase price. Credit insurance, however, enables the manufacturer to be more liberal, to some extent, in granting credits. This may be of decisive importance in times when competition is high. It is also a good protection against losses due to rapid and unforeseeable changes in general economic conditions. Finally, it may enable a manufacturer to benefit indirectly from the credit information of the insurance companies; the refusal by a company, after investigation, to underwrite insurance on an account will, for example, be considered as a reliable warning.

GENERAL CONCLUSION

As it was pointed out at the beginning of this chapter, a discussion of the effective demand, and especially a discussion of the purchasing power of the population, is, of necessity, dominated by considerations which change from day to day. The situation will, no doubt, have changed very substantially between the time this book is being written and the time it will be read and used.

The reader of the future will indeed be interested by the situation of his own day. To be really useful to him, the reading of this chapter should not be attempted without the assembling of new data. The extensive references of the preceding pages should greatly facilitate the necessary research work.

However, in the discussion of effective demand and of its two elements, the population and the purchasing power, permanent principles are involved, beyond the changing appearance of statistical data and yearly performances.

Effective demand is the support and the justification of production. They are bound to each other. The more so because every individual living in a modern country is at the same time a producer and a consumer. The problem of a prosperous economy in such conditions is neither to adjust the effective demand to production nor to adjust production to effective demand. It is rather to integrate both of them in a well-balanced "national plant."

For almost a century, a continuous increase in population provided such a dynamic economy that the necessity of integration was not always fully realized. Today, the population is no longer increasing at a comparable rate. The factor "purchasing power" takes its full importance. A real effort toward self-integration by business is needed.

"Just conducting research does not finish the job. To achieve the results sought, research findings and recommendations must reach and be understood by every group in America—and especially by the men and women who carry on the business enterprises of this country." *

* Donald Kirk David, Dean, Graduate School of Business Administration, Harvard University, addressing the Board of Trustees, Committee for Economic Development, July 12, 1946.

XVI

INDUSTRIAL EXPANSION

THE PROBABILITIES of future production in all lines of manufacture such as automobiles, radios, refrigerators, locomotives, and shoes, to mention a few, are not only of interest to those who manufacture the final product but also to those thousands of manufacturers who supply the materials and component parts of the final product.

The market for leather shoes, for example, is also the market for the tanner, and the manufacturer of rubber heels. The growth in demand for canvas and rubber-soled shoes is a matter of concern for the tanner of leather and a matter of interest to the producer of rubber goods. The builder of steam locomotives who expands his plant in anticipation of a future demand for railroad rehabilitation in which larger and faster trains are contemplated, is confronted with the rising demand for diesel-powered locomotives. If he has charted the course of the use of diesel power in railroad transportation, the locomotive builder will convert his facilities so as to meet the new de-

mands for diesel engines. The manufacturer of small industrial motors in contemplating his future market must chart the course of machine tool development, the trends in production of oil burners, of household refrigerators, and of other domestic equipment and industrial appliances driven by electric power. At the present writing, the Government's program of spending many billions of dollars for equipment for national defense and the rehabilitation of industrial equipment of other nations has given an impetus to industrial production which may well distort our estimates of future production for domestic and foreign peacetime needs. The manufacturer who has built up a profitable but small or medium-sized business is suddenly confronted with competition from a large and powerful company which has entered the field. With his better marketing and promotion facilities the large manufacturer may sometimes stop the future growth of the small manufacturer, and thus a business which has been expanded may either be stabilized at a fairly constant annual production or may need to retrench and adjust itself to a smaller market. In view of this even very curtailed statement of the conditions sometimes confronting the manufacturer, particularly one who operates a small or medium-sized business, what can be stated about the problem of industrial expansion which will be helpful to such a manufacturer in planning the future course of his business?

It appears that the future market for the products of any manufacturer is conditioned by three major external circumstances which are:

1. The activity of scientific research and development in the materials, processes, and products with which the manufacturer is concerned.
2. The strength of the competitive market.
3. The growth in use of the products manufactured.

Of course, if the internal circumstances of the business in the matter of its organization, management, and controls are faulty, the future market of the business is in jeopardy no matter what the external circumstances may be.

With respect to the three external circumstances which may effect the future market of any business, the following observations are of interest.

1. THE INFLUENCE OF RESEARCH

The increasing activity in all the arts, sciences, and technologies seriously challenges the stability of industry in the matter of materials

and processes used and products marketed. Scientific research is a constant hazard to present invested capital while at the same time it develops opportunities for the investment of the capital of the future.

Many metal products of yesterday, for example, which were formed by casting, forging, or stamping, today are molded from plastics. Many equipment items of metal manufacture of former years are now replaced by molding presses or have been redesigned for a more economical production of metal parts. The illustrations of the consequences of scientific research in the economic obsolescence of invested capital and in creating demands for new machinery and plants requiring new capital investments are almost endless. It is not our purpose to recount even a small percentage of them. Our interest is to indicate ways and means by which the manufacturer of today may deal intelligently with this problem as he plans for the future development of his business. Very large companies maintain research scientists and development engineers whose business it is to improve materials, machinery, and processes for the purpose of putting new products on the market or reducing the cost of manufacture of present products of improved quality. The small and medium-sized manufacturers usually cannot afford to equip and operate research and development laboratories and hence are often under constant threat of economic obsolescence of their present capital investment and the need for new capital for re-equipment purposes. This does not mean to state that all the improvements in the sciences and technologies of manufacture originate only with the larger companies, nor that the larger companies are not under threat of the economic obsolescence of their own equipment. This is far from the truth. It is maintained, however, that the hazards are greater for the small and medium sized manufacturing companies and their ways and means for meeting the situation are somewhat different.*

What ways and means are available to the smaller companies for meeting the problems which research poses? Experience has shown that the following policies have been effective:

a. At least one officer or executive in high position should be chosen for his understanding of the importance of scientific and technological developments related to the business.

b. An industrial scientist † should be on the staff of the company

* For a comprehensive and truly scientific study of the subject, see: "Report of the Chairman of the Special Committee To Study Problems of American Small Business." United States Senate, January 2, 1947.

† The industrial scientist is of course one who understands also the scientific aspects of industrial organization and management.

in full time service or be available for periodic consultation on recent scientific developments which may affect any part of the future of the business.

c. Scientific and technical reporting organizations such as *Science Abstracts* and the *Engineering Index* should be made use of; and those developments reported which may have a bearing on the company's products or processes, and the materials it uses, should be interpreted in relation to the company's future plans.

d. Appropriate budget provisions should be made for experimental developments which current scientific trends may indicate will be fruitful.

e. Appropriate and adequate reserves should be set up to assure the capital needed for new equipment to replace that which is becoming obsolete and which should be retired.

The above focal areas in policy formation, when implemented by adequate procedures and competent personnel, should serve to *insure* a company not only *against* the hazards of scientific research and technological development but *assure* the successful future of the company in the matter of materials, organization, processes, manufacturing equipment, and marketable products.

2. THE COMPETITIVE MARKET

The economic policies of small and medium-sized manufacturing businesses with respect of the competition offered by the larger and more powerful companies are not easily formulated because of the varying nature of such competition. As a general rule, the following matters are to be taken into account:

a. The economy of location and the limits of growth appropriate thereto. The meat packing industry provides a good illustration on this point. In this industry the cost of material (cattle, hogs, and sheep, on the hoof) is a very large factor in the cost of the final product, as much as 80 percent in some cases. This, together with freight charges on the delivery of meat to the consumer makes it possible for small abattoirs to do a profitable business to supply the local markets. Cement block plants, garment factories, laundries, bakeries, machine shops, lumber mills, and a host of other industries may be favorably located as to markets and raw materials supply, so as to meet successfully the competition of larger companies not so favorably situated as to local markets and sources of supply. The policy of industrial expansion by such companies should be largely

influenced by the growth in population and the purchasing power of the community served, as set forth in the preceding chapter. The program of capital investment in such businesses should be based on a policy of economy in production rather than on increase in size for the purpose of serving customers beyond the bounds within which the economic advantage of the business extends.

b. Federal legislation. At the present writing, the competitive market is seriously affected by the recent rulings of the Supreme Court on delivered pricing practices in the cement industry. If this decision should result in the elimination of the use of basing points as discriminatory and illegal under the Robinson-Patman Act, it may affect the pricing practices of over 100,000 business firms in a wide variety of industries. It is too early to predict the final outcome in the situation. Congressional legislation and further court rulings respecting the practices of specific industries against which the Federal Trade Commission may issue cease and desist orders are needed before the situation can become stabilized. But this example will serve to illustrate the fact that among the important external circumstances which may affect the competitive market and thus influence for good or for ill the future markets of any company are the trends in court decisions and federal legislation in the regulation of business practices. Such decisions may result in an opportunity for some companies to expand their markets while other companies will be adversely affected. The policy of expansion of any company should be reviewed with reference to the trend in government policy which may affect the markets it now serves.

For some years a number of large companies have expanded their markets through the acquisition of the assets subject to the liabilities of their smaller competitors. By this means they have avoided the technical violation of the antitrust laws which prohibit the *merger* or *consolidation* of businesses to the point where a dominant portion of the market is in control of one corporation. The smaller company sells its assets—against which act there is no law—and simply goes out of business. It may very well be that some future Supreme Court ruling concerning this practice may have a marked effect on industrial expansion.

3. GROWTH IN THE USE OF PRODUCTS MANUFACTURED

Individual businesses may either expand their markets or have to retrench in the face of competition, but the sum total of the annual in-

crements of expansion of all companies in a given industry seems to be conditioned by a characteristic phenomenon of growth which we will now explain.

When the size of the population of the United States from year to year is plotted as shown in Figure 65, it is found to follow a pattern quite similar to that observed when one plots the height or size attained day by day by a plant such as a *Citrus lemon* as shown in Figure 76. The characteristics of this pattern are that in the earlier period of growth the change in size is very gradual; in the middle

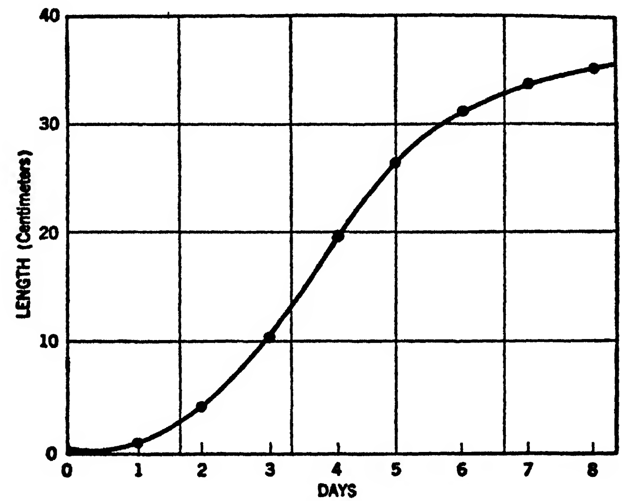

Figure 76. The Growth of a Lemon Shoot in Length

period there is a marked increase in the rate of expansion; and then there follows a period of maturity marked by a decrease in the *rate* of expansion or growth and a subsequent tendency to stabilize.

Interestingly enough, when one plots the development of an industry such as automobile production or railroad construction it is found that these also tend to grow according to the same pattern as shown in Figure 77. The growth is not always regular in the sense that in each succeeding year there is an increase in production. In the case of automobile production, for example, the period from 1907 to 1929, showing a consistent trend in pattern, was characterized by a series of periodic recessions, as shown in Figure 78. But the main pattern of growth was followed. What causes bring about this growth pattern for populations, plants, and industries? In the matter of popu-

lation and plants there are certain biological factors which condition growth that need not detain us in our studies. In the matter of industrial production the following observations may be of interest. The earliest models of automobiles, radios, and household refrigerators, to mention a few more recent types of products, were rather crude affairs, produced at costs which limited the number of possible purchasers, and furthermore were not among the conscious needs of the public. The earlier periods of these industries were marked by a

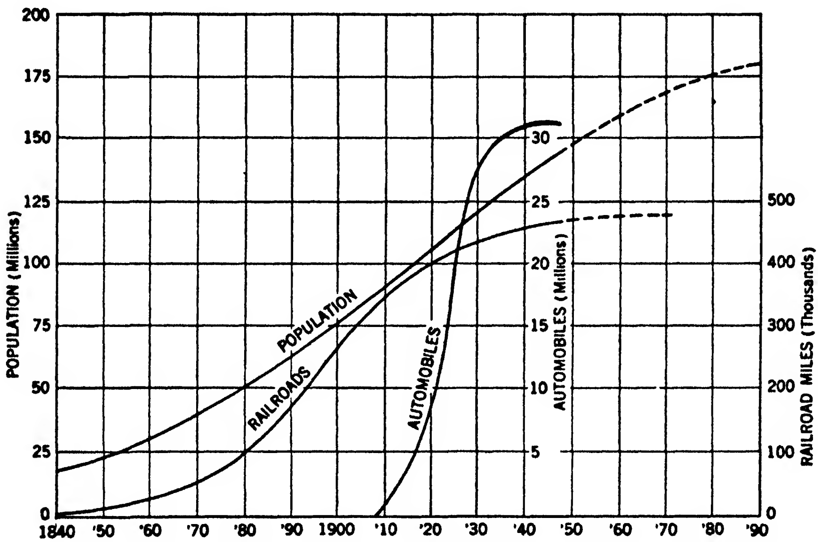

Figure 77. The Growth of Population, Railroads, and Automobiles in the U. S. A., 1840–1948

rather gradual increase in annual production. With improvement in quality of product, and the development of more economical methods of manufacture, public acceptance was rapidly gained and the market area was increased by lower pricing. During this period, the profits made became attractive, investment capital flowed to the industry and rapid industrial expansion took place. The later phases of the period of industrial expansion are the most critical for reasons which are not far to seek. In the expanding years of an industry there are two classes of customers, those who are buying this type of product for the first time and those who are buying for replacement. Accordingly, the composition of the curve of annual production during this period is as shown in Figure 79. In time, the market tends to become

saturated, the number of new customers becomes a smaller portion of the total, and the production for replacement tends to dominate. In a few years after this period, the annual production to supply new customers becomes less and less while the production for replace-

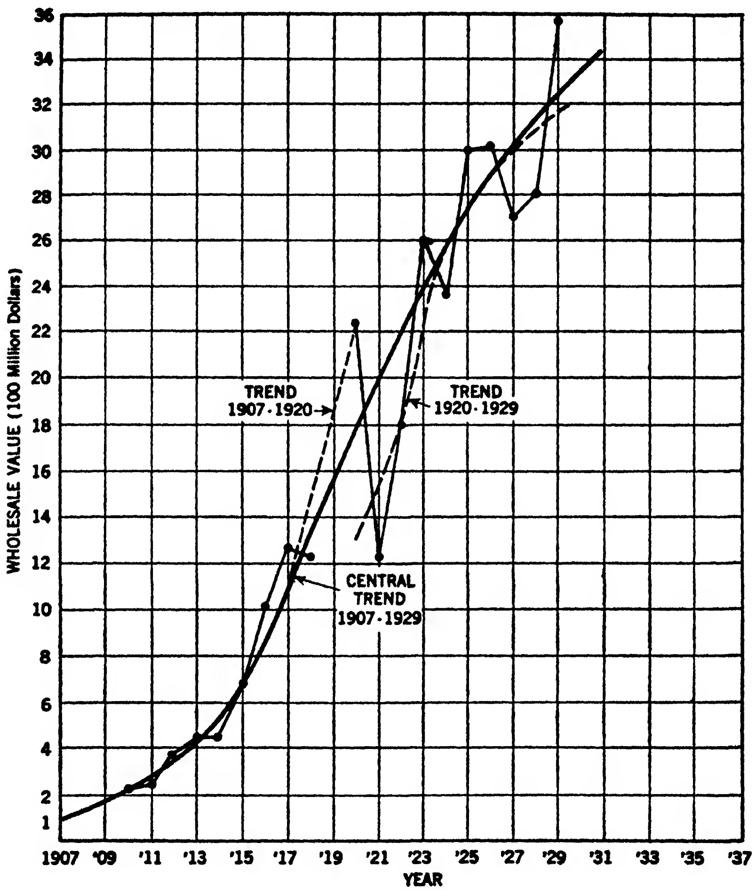

Figure 78. Growth of Automobile Factory Sales, U. S. A., 1907–1929

ment continues to rise, as shown in Figure 80. Total production may therefore decline until such time as the replacement market dominates and total production rises again and becomes stabilized at a trend corresponding to the growth in population. This situation is illustrated in Figure 81 which shows the growth of the automobile passenger car production in the United States from 1900 to 1947.

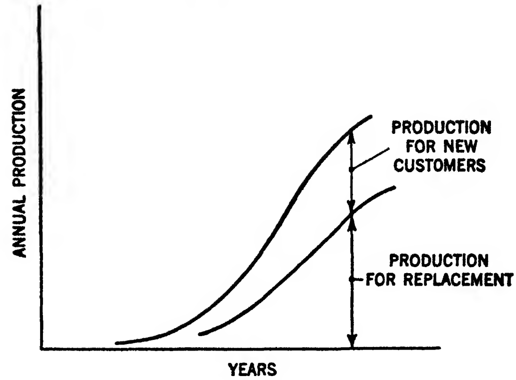

Figure 79. General Pattern of Annual Production of an Industry from Its Inception to Maturity

When the whole economy is distorted due to war or to a defense program, the market for civilian goods also becomes distorted and the growth patterns of some industries may be materially altered for a period of time. This imposes an additional and very complex problem not only concerning industrial expansion but also concerning the maintenance of present levels of production in some lines. For example, the present diversion of stock, from use in the production of consumers' goods to the production of stock piles of defense equipments, changes the pattern of growth by suppressing the production of some civilian goods and introducing a new customer, the government.

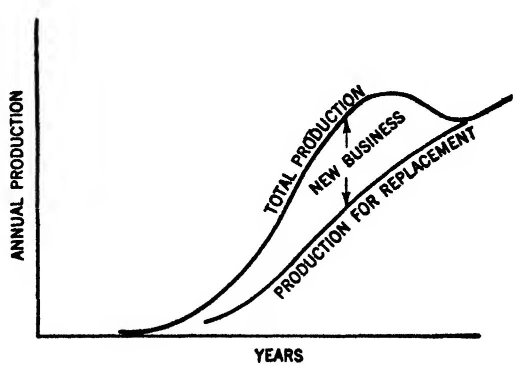

Figure 80. General Pattern of Annual Production of an Industry Particularly During Post-maturity

Demand which stimulates production is accordingly of a new order, the character of which is dependent on government policy in relation to world events. The pattern of industrial growth at the present time is also influenced by government policies and programs for the rehabilitation of European and Asiatic lands which have been devastated by the recent World War.

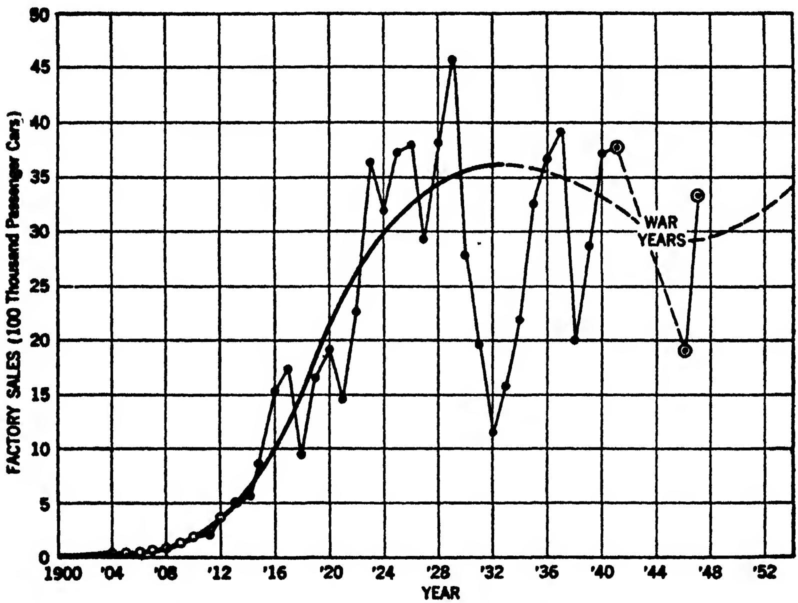

Figure 81. Factory Sales of Passenger Cars with Pattern of Trend U. S. A., 1900–1947

These extraneous but dominant forces, imposed on what may be termed the normal patterns of peacetime industrial expansion, make the course of company future policy with reference to production an exceedingly difficult one to formulate. The problem becomes more complex in view of the fact that the government is not only a more dominant customer but, as in the last war, it becomes a partner as to the risks of investment undertaken to meet its production demands. The formulation of government policy with respect of such risks is not readily predictable and hence the hazards to private capital investment in such a program of industrial expansion are not easily foreseen. In view of all these circumstances which are presently affecting the course of industrial expansion, it is not possible to formu-

late any guiding principles concerning either policies or procedures in this respect. Accordingly, we are forced to await the consequences of world events and the results of our national policies in relation thereto before we can see clearly the economic factors which should determine the future course in the matter of industrial growth and development.

APPENDIX

The relation of industrial expansion to standardization has been very clearly shown by Dr. John Gaillard, of the American Standards Association, lecturer in the Department of Industrial Engineering at Columbia University, in his doctoral dissertation, from which we quote as follows:

PROGRESS-TIME CURVE

Industrial progress due to new basic ideas (discoveries and inventions) plotted against time is represented by a continuously rising curve. The practical application of such basic ideas cannot follow such a curve. The development of each of them into the regular manufacture of a product or some other industrial activity requires time for building up the necessary machinery, figuratively, and in most cases literally, speaking. The best that can be attained is the approximation of the progress-time curve by a broken line. The horizontal parts of this line represent levels on which practice will be based during successive periods of time, independent of the rise made in the meantime by the progress curve. The vertical parts represent the shifts from each level to the next one. The graph in Figure 82 representing the development of a manufactured product * from the moment of its basic conception will illustrate this point. This development may be divided into three main phases. The first phase begins with the conception of a basic idea (a), which may be the result of invention or discovery. For a long period of time this basic idea may remain unsuitable for practical application because certain indispensable elements are still lacking. There may be a gap in the technical solution, or the technical solution may be complete but still too expensive for economic application. In both cases the world has to wait for one, or perhaps further inventions or discoveries.†

* The curve representing the development of a composite product may be considered as resulting from the combination of similar curves applying to its elements which at a particular time may or may not be in the same phase of development.

† The basic form of the present airplane (monoplane) was known to be suitable for mechanical flight about ninety years ago. In 1842 Stringfellow built a model driven by two propellers which was the first to make a flight (Encyclopedia Britannica, 14th Edition, Vol. 1, page 243). However, the airplane as a means of transportation had to wait for the development of an engine with a high enough power-to-weight ratio.

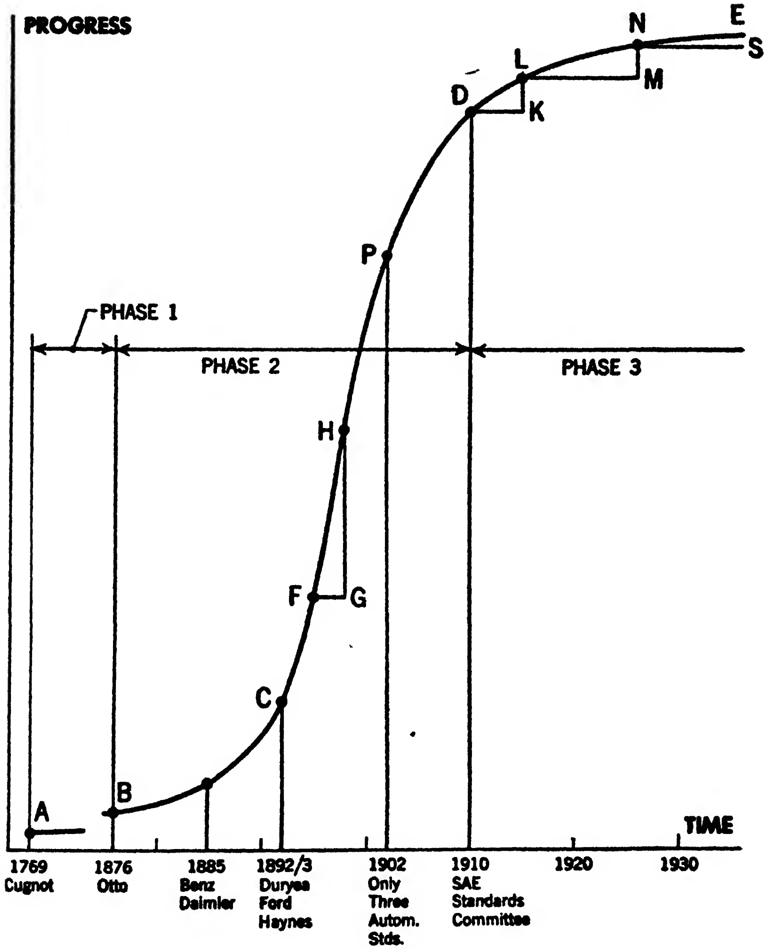

Figure 82. Progress—Time Curve

Once the chain of elements required for the practical application has been completed, the basic idea becomes the beginning of an actual industrial development (b). This is also the end of the first main phase A-B which might be called the "latent" phase.

From the point B on, the rate of progress will increase. At first, many problems of secondary importance have still to be solved * but the product is being manufactured and tried out in practice, be it still in very small numbers (stage B-C). At C the product has found a market, and manufac-

* For example, the ignition and the carburetion systems of the gasoline engine, in its early days.

ture is started in greater volume. Mutual induction between the efforts of industry to perfect the product and the results of practical experience gained with its use cause a steep rise of the progress curve from then on. Improvements follow each other in quick succession. The entire second main phase B-D might be called the "development" phase whose early portion B-C still has an entirely experimental character. During it, the product acquires a definite form as to its essential features.

From D on, only minor improvements are made.* Accordingly, the progress curve flattens out and approaches the horizontal direction asymptotically. This third main phase D-E might be called the "saturation" phase.† In general, it is not possible to determine exactly the point where the second phase changes over into the third. (Contrasting herewith, the transition from the first phase to the second is often quite distinct.) The third phase may last until a further basic improvement causes a new rise in the progress curve, or until the manufacture of the product is abandoned because the latter is superseded by a competitive one.

A progress-time curve of the kind described cannot be recorded in an exact manner, as it is impossible to assign a definite progress rating to each development causing a rise in the curve.‡ It is possible, however, to determine its general shape on the basis of the considerations mentioned above. This is sufficient for our present purpose, namely to determine that point of the curve where industrial standardization may successfully be started. In practice the decision whether this point has been reached must be taken on the basis of the conditions observed to exist in each individual case. This is due not only to the fact that the progress cannot be rated in an exact manner, but also to the circumstance that the state of the art is only one among several factors influencing a program of standardization. Business policies of interested groups may delay the undertaking of standardization work well beyond the point where it becomes feasible in so far as technical progress is concerned.

The progress curve and the temporary levels or standards show at a glance what it means to have no standards at all, as well as the consequences of adhering to a standard for an unduly long period of time. If there are no standards at all, the progress curve will dictate continuous changes, thus preventing the full development of any particular form of the product. Adhering to a standard too long means that the gap between the progress curve and the level of the standard is allowed to become too wide. This situation will make the adjustment to the progress curve, once it must be made, extremely difficult. Also, the delay suffered in making this adjustment may result in a permanent loss of business through obsolescence of the product or through its being overtaken by a competitive product.

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* For example, the bicycle in Europe during the last 30 years.

† The "saturation" is meant to apply to the progress in the art, and not to the market of the product.

‡ In the evolution of the automobile industry, for example, we may single out the several steps leading up to the present type of gasoline engine; the application of interchangeable manufacture and continuous flow production; the development of special machine tools and of alloy steels; and the results of the research work on fuel problems carried out during recent years.

WHEN STANDARDIZATION CAN BEGIN

The graph in Figure 82 shows that standardization cannot be applied before the point D of the progress curve, the beginning of the third phase, has been reached.* During the first phase A-B, there is not yet any question of an industrial development properly speaking. This is true even through a considerable amount of research data on basic facts may have been collected by the industry concerned. The second phase B-D is at first an experimental one. Its part C-D is characterized by rapid development involving frequent changes and considerable improvements of a more or less fundamental nature. If a standard were set up during this phase, say at F, revision would become necessary shortly afterward, say at G. No coordination, the second function of standardization, can be started on the basis of a level of conditions which itself remains stable for only a relatively short period of time (F-G). When the beginning D of the third phase has been reached, a large market had been secured for the product. The rate of the latter's improvement, at least in respect to essentials, has slowed down. Agreement has been reached, explicitly or implicitly, on the type, the performance requirements, and in many cases even on the main dimensions that are most desirable for the product with a view to its practical use; but, due to lack of coordination of such agreement, no definite and general uniformity exists as yet. However, conditions are now favorable for the successful undertaking of this coordination. If D is the point where it is started, this means that industrial practice will temporarily follow the horizontal line D-K instead of the progress curve D-E. In the meantime, basic progress continues to move along this curve. The increasing distance between the latter and the level of the standard D-K creates a growing "pull" which tries to force industry off the adopted level D-K, so that it may adopt the latest improvements. As long as the benefits derived from the existing standardization plan still exceed those to be gained by changing over to the new practice, the standard D-K will hold its own. As soon as the stability of the standard is overcome, a new standard, say L-M, will be set up as a revision. Provision must therefore be made, in setting up the original standard, to permit such a change to occur without undue hardship when the "pull" toward improved practice becomes strong. Else the result will be that industry abandons the old standard in its actual practice. This clearly indicates that there is a fundamental danger of overstabilization in standardization work which may be due to different causes. . . .†

When a new standard L-M has been established, the same phenomenon is repeated. The graph shows that if the "pull" required for a change in the standard remains the same—being equal to K-L, in terms of progress—the standard L-M will remain valid for a longer period of time than the

* It may be possible to standardize certain components of a product before standardization of the entire product can be undertaken. The individual curves of these components have then reached their respective points D without this being the case for the composite curve.

† The change from one standard to another under the influence of progress in the art may be likened to the shift in position of an engine governor which occurs when the speed of the engine has increased by a certain amount.

standard D-K. The same statement will be true for each subsequent revision of the standard, such as N-S. Finally, the time comes when the progress curve runs so closely to the latest standard level that no tendency to depart from this level develops. In this way, a "stabilization of the standard" may ultimately result, unless special causes, such as a change in the demands of the buying public, upset this condition.

PROBLEMS

CHAPTER I

1. What classes of legal instruments or certificates of ownership may a corporation exchange for the money or credit entrusted to it? What are the general characteristics of each class?
2. What is meant by the efficiency of conversion of certificates of ownership into money or credit?
3. Does the vendor who furnishes materials to a company on open accounts provide the company with part of the credit referred to in the first phase of the economic flow chart? Explain.
4. When a company obtains money or credit through selling its bonds through an investment banker and the banker charges 10 percent of the face value of the bonds for his services, is that more or less of a hazard than if the funds were raised through the sale of common stocks, also at a discount of 10 percent? Explain.
5. What are some of the criteria of efficiency in the second phase of the economic flow chart in the procurement of (a) Land, (b) Buildings, (c) Machinery?
6. How does an inefficiency in the second phase of the economic flow chart compare with an inefficiency in the third phase so far as control is concerned? Explain by illustrative situations.
7. State what the industrial engineering profession has done to assist management in accomplishing efficiency in the third phase of the economic flow chart.

8. Explain how the second and third phases of the economic flow chart are related with respect to efficiency.
9. A manufacturer invests $1,000,000 in plant and equipment and, in addition, has $300,000 available for working capital. What inquiries should be made concerning the adequacy of the amount of working capital?
10. Illustrate by an example how the "values" of fixed assets, materials, and services flow into the values of the products of manufacture.

CHAPTER II

1. Some of the amounts stated as "values" in the balance sheets and the profit and loss statement are, in many cases, estimated values. In what sense may this be true, or untrue, of such items as:

   (a) Accounts receivable
   (b) Inventory
   (c) Machinery (depreciated value)
   (d) Current liabilities
   (e) Cost of manufacture
   (f) Net profit
   (g) Cash.

2. In a balance sheet, dated December 31, the item of interest on bonds due January 1 is not listed under current liabilities. Does this represent good accounting practice? Explain. If, in the same case, a portion of the bonds are due for retirement on October 1, should this amount appear as a current liability?
3. A company earns $500,000 in a given year. May the directors always declare any of this amount as dividends? Explain.
4. Since inventory is an item in current assets, what inquiry should be made as to the nature of the inventory before acceptance of the value stated for inventory as a sound value?
5. A company lists among its assets a value of $500,000 for dies which it uses in manufacturing its products. What inquiry should be made concerning the dies before accepting the $500,000 as a sound value?
6. A company shows a gross profit of 30 percent on sales for a given month. Some time later its monthly sales are doubled and its gross profit is 40 percent on sales. Does this seem reasonable or not? Explain.
7. Prepare a diagram to illustrate the flow of values of the asset items of the balance sheet.
8. Obtain the published balance sheet of any manufacturing company and express it in the condensed form shown in Table II.
9. Obtain the published profit and loss statement of any manufacturing company and determine the following items as percentage of sales:

   (a) Cost of goods sold
   (b) Gross profit
   (c) Administrative expense
   (d) Selling expense
   (e) Operating profit
   (f) Net profit.

   From the balance sheet of the same company, find the net worth and determine the net profit as a percentage of net worth.

(*Continued on page 416*)

TABLE A

CONDENSED PROFIT AND LOSS STATEMENT

(Millions of Dollars)

INCOME AND EXPENSES	All Industries	Food	Textile Mill Products	Furniture and Fixtures	Paper and Allied Products	Chemicals and Allied Products	Rubber Products	Leather Products	Machinery
Net sales	37,279.0	7,967.7	2,087.6	414.7	1,292.5	2,582.0	826.6	595.0	3,053.3
Costs and expenses	33,403.6	7,378.2	1,840.5	372.8	1,073.1	2,250.1	768.7	556.7	2,708.4
Net operating profit	3,875.4	589.5	247.1	41.9	219.4	331.9	57.9	38.3	344.9
Other income or deductions—net	73.6	−8.5	4.3	−.9	−2.2	13.2	−1.5	1.2	7.2
Net income before Federal income taxes	3,949.0	581.0	251.4	41.0	217.2	345.1	56.4	39.5	352.1
Provision for Federal income taxes	1,525.7	235.1	100.8	16.6	84.1	132.1	29.9	16.5	142.7
Net income after taxes	2,423.3	345.9	150.6	24.4	133.1	213.0	26.5	23.0	209.4
Dividends paid (cash or in kind)	799.2	108.7	53.3	3.6	32.9	103.9	12.7	7.5	66.7

TABLE B

CONDENSED BALANCE SHEET

(Millions of Dollars)

	All Industries	Food	Textile Mill Products	Furniture and Fixtures	Paper and Allied Products	Chemicals and Allied Products	Rubber Products	Leather Products	Machinery
ASSETS									
Cash	11,461.5	1,445.7	725.7	85.8	398.0	1,065.1	210.0	138.3	1,100.1
U. S. Government securities	6,394.1	702.2	521.9	55.8	316.8	762.6	78.5	64.6	433.3
Other marketable securities	647.4	108.2	64.8	6.0	33.6	86.6	1.8	7.3	58.2
Accounts and notes receivable—net	12,191.7	1,475.7	783.6	153.6	391.1	902.4	389.5	264.1	1,290.5
Inventories	25,516.9	3,748.3	1,468.3	273.2	664.5	1,741.9	638.0	367.7	2,988.7
Other current assets	683.2	106.7	41.8	5.4	20.7	62.9	2.4	6.4	54.9
Total current assets	56,894.8	7,586.8	3,606.1	579.8	1,824.7	4,261.5	1,320.2	848.4	5,925.7
Property, plant, and equipment—net	31,045.4	3,223.6	1,396.5	216.0	1,477.5	2,490.3	526.9	151.8	2,098.3
Other assets, including deferred charges	6,694.3	718.7	284.4	30.7	334.1	1,018.4	62.4	56.4	547.4
Total	94,634.5	11,529.1	5,287.0	826.5	3,636.3	7,770.2	1,909.5	1,056.6	8,571.4

TABLE B (CONTINUED)

CONDENSED BALANCE SHEET

(Millions of Dollars)

	All Industries	Food	Textile Mill Products	Furniture and Fixtures	Paper and Allied Products	Chemicals and Allied Products	Rubber Products	Leather Products	Machinery
LIABILITIES									
Bank loans payable within one year	2,488.6	688.6	144.9	39.3	53.5	109.6	29.4	42.3	276.4
Other notes and accounts payable	6,858.4	786.9	384.1	63.0	178.4	415.9	166.5	113.8	623.3
Federal income taxes accrued	6,706.9	986.4	519.3	67.1	338.4	673.2	125.3	87.5	615.3
Other current liabilities	4,295.2	381.9	196.0	36.0	119.7	280.2	104.5	33.2	563.7
Total current liabilities	20,349.1	2,843.8	1,244.3	205.4	690.0	1,478.9	425.7	276.8	2,078.7
Long-term debt and other liabilities	8,321.2	1,121.1	223.2	43.5	309.3	518.3	272.2	15.0	625.7
Stockholders' equity	65,964.3	7,564.3	3,819.4	577.5	2,636.8	6,132.9	1,211.5	764.8	5,867.1
TOTAL	94,634.6	11,529.2	5,286.9	826.4	3,636.1	8,130.1	1,909.4	1,056.6	8,571.5

10. A company at the close of a given year shows an operating deficit (− operating profit) and yet its net profit for that year is a substantial amount. Explain how this may come about.

CHAPTER III

1. The Federal Trade Commission and the Securities and Exchange Commission in their Quarterly Industrial Financial Report Series for all United States manufacturing corporations, issued March 17, 1948, reported the third quarter condensed financial statements of all the manufacturing industries in the United States, from which the following have been selected. See TABLES A and B (the Profit and Loss Statement is for one quarter only).
   a. Derive the significant ratios of each industry.
   b. Compare the ratios among the industries.
   c. Suggest what meaning may be attached to the comparisons.
2. What is meant by the stability of a company's financial situation?
3. Illustrate by examples a financial structure which, in your opinion, is stable, and one which is unstable.
4. Give an example of the capital structure of a company in which the common stock holdings are (a) conservative, (b) speculative.
5. Give an example of an unstable ratio of debt to net worth, and explain.
6. List the inquiries one should make in examining the significance of a ratio of current assets to current liabilities.
7. What occasions require the establishment of reserves?
8. What matter of production operation should be examined in an attempt to reduce the ratio of inventory to sales?
9. A certain company has a ratio of annual sales to net worth of 200% and makes a profit of 10% on sales. Another company has a ratio of annual sales to net worth of 300% and also makes a profit of 10% on sales. Compare the stockholders' earnings in the two cases.
10. Obtain the profit and loss statement of any company and derive its cost ratios.
11. Set up a comparative balance sheet and show what disposition is made of the earnings of the period of comparison.

CHAPTER IV

1. The corporate sales from 1929 to 1946 of all industries and the important subdivisions of industry were reported by the United States Department of Commerce.* From these reports the following selections are made:

* Supplement to *Survey of Current Business*, July, 1947.

TABLE C

CORPORATE SALES—1933 to 1946

(Millions of Dollars)

Year	All Industries *	Metal Mining	Food	Electrical Machinery	Wholesale Trade	Textile Mills	Railroads
1933	73,027	375	7,744	536	11,166	3,074	3,520
34	89,553	375	9,266	764	17,731	3,402	3,720
35	101,953	504	10,491	923	20,479	3,915	3,853
36	119,462	671	11,895	1,263	23,771	4,445	4,511
37	128,884	939	12,542	1,554	24,391	4,471	4,630
38	108,651	598	11,615	1,565	19,577	3,210	4,138
39	120,789	798	10,877	1,844	21,314	3,869	4,632
40	135,248	973	12,372	2,462	23,532	4,207	4,722
41	176,181	1,095	15,767	3,747	29,707	6,068	5,840
42	202,777	1,260	20,602	5,002	29,026	7,616	7,887
43	233,525	818	22,373	6,585	30,306	8,011	9,610
44	244,342	752	23,715	7,988	32,397	7,634	10,004
45	237,303	643	23,193	7,245	34,017	7,657	9,434
46	245,508	582	24,979	4,354	42,521	9,426	8,085

* Except finance, real estate, and insurance.

The corporate profits before Federal and State Income and Excess Profits taxes of the above industries are reported as follows:

TABLE D

CORPORATE PROFITS (BEFORE TAXES) 1933 to 1946

(Millions of Dollars)

Year	All Industries	Metal Mining	Food	Electrical Machinery	Wholesale Trade	Textile Mills	Railroads
1933	162	17	341	−14	94	157	−275
34	1,723	55	397	−15	217	33	−255
35	3,224	84	406	64	257	78	−174
36	5,684	140	519	135	427	189	−34
37	6,197	245	345	170	360	102	−62
38	3,329	117	360	82	142	−16	−254
39	6,467	182	543	185	358	172	−12
40	9,325	236	559	342	492	216	80
41	17,232	273	881	720	1,028	618	517
42	21,098	302	1,244	708	1,111	863	1,591
43	24,516	181	1,513	843	1,259	831	2,272
44	23,841	148	1,524	882	1,323	805	1,843
45	20,223	101	1,407	603	1,388	774	1,230
46	21,140	104	1,748	48	1,858	1,435	282

(a) Plot the corporate profits in relation to corporate sales for each of these industries.

(b) Derive the equation of the line of central trend of profits *vs.* sales for each of the industries.

2. Plot the profit and loss charts of the National Cash Register Company from the following data found in Moody's *Financial Manuals* (*Industrial*). Make a separate chart for each group of expenses.

Year	Sales	Cost of Goods Sold	General and Administrative Expense	Total Expense
	(*Millions of Dollars*)			
1945	68.44	39.97	26.83	67.00
44	93.77	61.54	24.24	91.17
43	99.17	65.65	22.87	97.04
42	79.88	45.81	22.99	78.19
41	52.40	24.92	21.11	49.97
40	38.77	17.45	17.89	37.41
39	37.08	15.75	18.42	36.00
38	36.22	17.20	15.85	34.68
37	42.27	18.52	18.05	38.94

Determine the equation of trend of each group of expenses in relation to sales.

3. The United States Census of Manufacture (1940) reports the following data on Pulp Mills, Paper and Paperboard Mills:

Year	Value of Products	Cost of Materials, Supplies, Fuel, etc.	Wages
	(*Millions of Dollars*)		
1939	1,159.86	676.99	175.68
37	1,205.13	721.10	175.65
35	879.00	525.49	130.60
33	695.65	393.66	99.19
31	851.53	495.08	126.88
29	1,206.11	723.76	173.07
27	1,029.53	615.55	162.00
25	971.88	605.86	160.14
23	907.34	573.72	151.47
21	667.43	445.99	127.02
19	788.05	467.48	135.69
14	332.14	213.18	53.24
09	267.65	165.44	40.80
04	188.71	111.25	32.01

Plot wages *vs.* value of products and materials *vs.* value of products and derive the equation of trend for each.

4. Plot the gross profit and loss chart of the Granite City Steel Company, Inc., from the following data:

Year	Sales	Cost of Sales
	(*Millions of Dollars*)	
1943	17.22	14.81
42	17.73	15.12
41	18.68	16.25
40	11.67	9.94
39	10.21	8.45
38	6.35	6.20
37	13.23	12.50
36	10.11	9.46
35	8.08	7.04
34	5.18	4.58

Determine the equation of trend of gross profits in relation to sales.

5. The combined sales and total expenses of General Motors, Chrysler, Packard, Hudson, Studebaker, and Nash-Kelvinator automobile companies are reported as follows:

Year	Sales	Total Expenses
	(*Millions of Dollars*)	
1941	3,745.05	3,166.17
40	2,840.02	2,471.58
39	2,214.53	1,946.52
38	1,677.54	1,562.21
37	2,727.45	2,435.12
36	2,369.70	2,028.16
35	1,855.74	1,635.99
34	1,333.07	1,238.89
33	895.41	805.71
32	671.79	689.71
31	1,161.20	1,059.94

Plot the trend of total expenses to sales and derive the equation of the trend line.

6. The records of a certain manufacturing company were analyzed to determine the probable division of each item of total expense into variable total costs and constant total costs. The results of this analysis were as follows:

ESTIMATED MONTHLY VARIABLE AND CONSTANT TOTAL COSTS

Percent A	Percent B	Items	Cost per Month in Dollars A Variable	B Constant	Total
		Manufacturing Costs			
100		Raw materials	31,161.92		31,161.92
	100	Direct labor	....	12,359.05	12,359.05
	100	Foremen's salaries	....	1,660.00	1,660.00
100		Operating supplies	2,068.05	....	2,068.05
100		Packing supplies	5,420.00	....	5,420.00
	100	Repairs (production departments)	....	2,572.00	2,572.00
	100	Water	....	100.00	100.00
100		Fuel	3,037.87	....	3,037.87
	100	Steam labor and expenses	....	2,355.25	2,355.25
	100	Steam repairs	....	667.00	667.00
	100	Boiler installation and fixed charges	....	126.81	126.81
81	19	Power purchased	4,173.20	1,000.00	5,173.20
	100	Power labor and expense	....	950.00	950.00
	100	Power repairs and maintenance	....	318.00	318.00
	100	Fly wheel installation and fixed charges	....	125.32	125.32
33	67	Sub packing station power	40.00	80.60	120.60
	100	Refrigeration labor and expense	....	473.00	473.00
	100	Refrigeration repair and maintenance	....	426.00	426.00
	100	Refrigeration fixed charges	....	12.25	12.25
33	67	Sub packing station refrigeration costs	150.00	299.70	449.70
	100	Salaries, supervision of plant	....	1,590.00	1,590.00
	100	Salaries, superintendent of plant (fixed charges)	....	5,600.00	5,600.00
	100	General repair and maintenance	....	971.00	971.00
	100	Plant office expenses	....	1,575.00	1,575.00
33	67	Trucking, salaries, and expenses	291.00	600.00	891.00
	100	Trucking, fixed charges	....	262.68	262.68
	100	Yard costs	....	1,225.00	1,225.00
	100	Liability and compensation insurance	....	273.95	273.95
	100	Experimental expenses	....	800.00	800.00
	100	Traveling expenses	....	400.00	400.00
	100	Unclassified general expenses	....	28.00	28.00
	100	General taxes	....	309.29	309.29
	100	Fire insurance, general	....	428.27	428.27
	100	Depreciation	....	3,699.50	3,699.50
		Total manufacturing costs	46,342.04	41,287.67	87,629.71
		Less destroyed and samples	633.20	....	633.20
53	47	Net manufacturing costs	45,708.84	41,287.67	86,996.51
100		Freight and express	16,545.79	....	16,545.79

		Branch Operating Costs			
100		Gasoline and oil	3,287.22	....	3,287.22
100		Tire repairs	207.65	....	207.65
100		Auto repairs	1,650.05	....	1,650.05
100		Express and parcel post (outgoing)	1,232.25	....	1,232.25
100		Refrigeration, ice, etc.	1,134.50	....	1,134.50
100		Reserve for bad debts	2,000.00	....	2,000.00
	100	Salaries	....	29,420.40	29,420.40
	100	Other branch expenses	....	11,478.04	11,478.04
19	81	Total branch operating	9,511.67	40,898.44	50,410.11
	100	Division sales expense	....	11,690.00	11,690.00
	100	Administrative, and general sales expense	....	18,720.90	18,720.90
		Total administrative, general sales division sales expense	....	30,410.90	30,410.90
39	61	TOTAL COSTS	71,766.30	112,597.01	184,363.31

The above estimate is based on a production of 1,000,000 pounds of product per month. The company manufactured a food product which was sold to the baking trade by the pound. It had 65 branches throughout the United States, and two manufacturing plants. The product was sold at an average price of 20.5¢ per pound.

Thus lay out the break-even chart for this company for a range of production up to 1,500,000 pounds per month, with the base of the chart in units of 100,000 pounds per month. Show the total expense trend, net manufacturing cost trend, and the trend of total expenses before administration and general sales expense.

7. Construct a break-even chart from the above data with the base laid off in units of income in which the income line is at 45°. If the selling price of the product should be reduced to 19¢ per pound, at what income will the company break even? Draw the total expense line for this condition in a broken line on the chart. How much more business must be done to make the same profit as before?
8. A certain merchant went to his banker to obtain a loan of $20,000. He stated that current operations of his business were profitable and produced certain statements to support his assertions. The banker asked him the following questions and received replies as indicated.

Q. What is the average mark-up of your product?
A. 100 percent.
Q. How much is the total of rent, insurance, depreciation of equipment, and other items of fixed charges?
A. $20,000 per month.
Q. Are all employees on salary; is each necessary to the conduct of the business; what is the total of the monthly salaries?
A. All employees are on salary and each is necessary to the business. The total of their salaries is $7,000 per month.
Q. What other expenses are incurred in operating the business?
A. $1,000 per month for supplies, etc., and these are about the same each month regardless of sales.

Q. How much business must be done per month to break even?
A. About $40,000 per month.

Q. What is the anticipated average of the next 6 months' sales?
A. $50,000 per month.

Do you think the banker would grant the loan?

CHAPTER V

1. The following data are reported by the General Electric Company in its annual reports to stockholders:

GENERAL ELECTRIC COMPANY

Year	Net Sales	Total Operating Expenses
	(Millions of Dollars)	
1934	164.79	153.05
35	208.73	185.74
36	268.54	232.05
37	349.74	290.62
38	259.48	234.56
39	304.68	262.57
40	411.93	326.36
41	679.33	517.42
42	977.77	750.69
43	1,357.78	1,116.99
44	1,353.01	1,174.66

Plot total operating expenses in relation to net sales and derive the equation of trend.

2. The Westinghouse Electric Corporation reports its net income and net sales as follows:

WESTINGHOUSE ELECTRIC CORPORATION

Year	Net Sales	Net Income
	(Millions of Dollars)	
1934	92.15	0.18
35	122.58	11.98
36	154.46	15.09
37	206.34	20.12
38	157.95	9.05
39	175.07	13.85
40	239.43	18.98
41	369.09	23.11
42	487.27	17.36
43	709.34	21.40
44	830.48	24.90

Plot the relation between (net sales—net income) and net sales and derive the equation of trend.

3. The net sales and total expenses of the United States Rubber Company are reported as follows:

THE UNITED STATES RUBBER COMPANY

Year	Net Sales	Total Expenses *
	(Millions of Dollars)	
1934	105.47	106.02
35	127.79	119.96
36	160.36	150.18
37	186.25	177.64
38	154.93	149.05
39	195.31	185.09
40	228.98	217.56
41	315.34	301.68
42	294.01	285.63
43	434.26	420.09
44	450.73	434.90

* Includes: Cost of sales, depreciation, interest charges, income taxes, pension reserves, minority dividends, extraordinary expenses, provision for increase in depreciation, inventory adjustment.

Plot total expenses against net sales and derive the equation of trend.

4. The General Foods Corporation reports the following data for the years 1934 to 1940:

Year	Net Sales	Net Income before Taxes	Cost of Goods Sold
1934	$102,998,654	$13,070,584	$65,124,427
35	107,417,346	14,447,198	66,758,845
36	122,462,350	17,328,964	77,563,490
37	133,126,506	11,047,287	93,332,787
38	135,221,302	16,394,078	88,288,687
39	145,615,242	18,551,502	94,052,135
40	152,924,209	20,503,721	99,797,771

a. Compute annual total expense (net sales—net income before taxes).
b. Plot total expenses in relation to net sales and derive the equation of trend.
c. Plot cost of goods sold in relation to net sales and derive the equation of trend.
d. Compute annual administrative and selling expense (total expense —cost of goods sold).
e. Plot administrative and selling expense in relation to net sales and derive the equation of trend.

5. Certain-Teed Products, Inc., reports the following data for the period 1938 to 1945:

Year	Annual Sales	Net Income before Taxes	Net Income after Taxes
1938	$14,625,882	$ 206,391	$ 171,010
39	15,516,550	544,679	530,456
40	18,554,013	912,017	610,383
41	23,239,636	2,266,726	1,362,064
42	23,390,378	2,374,113	1,231,416
43	20,049,996	1,366,369	750,249
44	21,292,549	1,316,283	692,168
45	24,311,362	2,646,163	1,053,303

a. From the above data, compute total expense before and after taxes.
b. Plot total expense before taxes in relation to annual sales and derive the equation of trend.
c. Plot total expense after taxes in relation to annual sales and derive the equation of trend.

6. The following data are reported by the United States Gypsum Company in its annual reports to the stockholders:

Year	Net Sales	Net Income before Federal Taxes
1934	$ 15,950,000	$ 2,373,763
35	22,597,344	3,949,615
36	33,541,342	6,300,113
37	38,345,023	6,320,010
38	35,143,862	5,596,497
39	43,334,697	8,722,599
40	50,694,233	11,184,974
41	63,455,661	14,214,629
42	62,225,140	12,875,316
43	59,266,127	10,154,450
44	62,329,573	7,783,187
45	65,786,336	9,027,183
46	85,360,686	20,443,955
47	108,405,538	26,376,744

a. Compute total expense before Federal taxes.
b. Plot total expense before Federal taxes in relation to net sales and derive the equation of trend.

CHAPTER VI

1. Assume that the total expense trend of the ABC Company, as reported on page 140 is $4,500,000 + 60% sales.

a. What would be the equation of profit before Federal taxes?

b. If the capitalization should be \$12,000,000, 5% cumulative preferred stock, and \$25,000,000 common stock, what would be the profit on the common stock before Federal taxes for annual sales of \$17,000,000?
c. How many times would the company have earned its bond interest for both maximum and minimum sales for the period?
d. What is the equation after bond interest and Federal income taxes?

2. The total expense trend of a company's present break-even chart is \$6,000,000 + 60% of sales. The company has \$3,000,000 in 6% bonds outstanding; \$10,000,000 in 5% cumulative preferred stock; and 1,000,000 shares of no par value common stock.

   Determine the following for annual sales of \$20,000,000:

   a. The number of times bond interest may be earned.
   b. The number of times the dividends on preferred stock may be earned.
   c. The amount earned on common stock before Federal income taxes.

3. What effect on the earnings of the beet sugar company referred to on page 136 would result if the sugar content of the beets were 16 percent, percent of extraction 90 with a 5 percent shrinkage, and the molasses were reduced to one percent, but the selling price of both molasses and pulp were increased 20 percent, and all other factors were the same? Show the effect by a table of cents per pound cost at varying annual production.

4. Two companies, each with annual sales of \$3,000,000, make a net profit of 15 percent on sales. If one company (A) has constant total costs of \$800,000 and the other (B) of \$300,000, how do they compare with respect of earnings over a range of sales, when (A) has 50 percent more capacity than (B).

5. A certain manufacturer in Detroit, anticipating an increase in business, enlarged and mechanized his factory. His total expenses before factory enlargement followed the trend \$500,000 + 76% of sales. The plant enlargement increased the constant total costs 80 percent and reduced the variable total cost factor by 5 percent. How much more business than former full capacity (\$4,000,000 sales) must the company do to earn the same as it did at former full capacity?

CHAPTER VII

During the year 1948, the N— Corporation sold \$15,000,000 of manufactured goods.

The total expenses for the same period were \$12,000,000, including the following items of variable and constant expenses:

N— CORPORATION

	Total Expense	Percent Variable	Variable Expense	Constant Expense
Direct labor	$2,000,000	100%	$2,000,000	...
Direct material	5,000,000	100	5,000,000	...
Factory overhead	2,000,000	40	800,000	$1,200,000
Selling expense	2,000,000	60	1,200,000	800,000
General administrative expense	1,000,000	0	...	1,000,000
TOTAL	$12,000,000	=	$9,000,000	+ $3,000,000

Answer the following questions:

Problem 1. On the basis of the above data, how many dollars of sales are required for the N— Corporation to break even?

Problem 2. Assuming that there will be no substantial change in expense trends in 1949, what will the probable profit or loss be if the N— Corporation experiences a reduction of sales to $10,000,000 for the year 1949?

Problem 3. What is the amount of reduction in constant cost (regulated cost) needed for the N— Corporation to break even at $5,000,000 of sales (assuming that there is no change in the variable expense trend nor in the fixed expense)?

Problem 4. In December, 1948, the N— Corporation faces a demand by the union for a 10 percent increase in wages, in the form of a cost of living bonus. At the same time the raw material cost increases by 16 percent. Other expenses and selling prices remain at the same level as in 1948 (see data above). Prepare the probable break-even chart of the N— Corporation for the year 1949.

Problem 5. a. Using again the original data given for the year 1948, prepare the break-even chart of the N— Corporation *as it would be* if the selling price were reduced by 10 percent.

b. Where would the break-even point be in such a case?

Problem 6. The N— Corporation is considering the purchase of new equipment, to be installed in 1949.

It is estimated that if this new equipment had been available in 1948, the variable expense would have been reduced to $6,000,000 (instead of $9,000,000), due to a saving in labor cost. It is also estimated that the constant expense would have been increased to $5,000,000 (instead of $3,000,000), due to an increase in depreciation charges.

a. On the basis of this estimate and assuming that no other changes are expected in the expense-sales relationship, assuming also that the future sales will remain at approximately the same level as in 1948, is it advisable for the company to buy the new equipment?

b. Would it still be advisable if the sales were expected to drop to $8,000,000?
c. What if the sales should stabilize around $10,000,000?

7. In the case of the gas wells (page 175), assume that:

   a. Average drilling cost $10,000.
   b. Annual operating and overhead cost per well $800.
   c. Price of gas at well per MCF was 20¢.

   All other factors were the same as given on page 175.
   Reconstruct the table given on page 176 and the break-even chart, Figure 47.

8. In the case of the pipe-line (page 177), assume that the investment is $20,000,000, that the gas is purchased for resale at 6¢ per MCF and sold at the terminal at prices varying from 25¢ to 10¢ per MCF, the highest price gas being sold first such that gross revenues are 10 percent higher in each case as reported in the table on page 177. Also assume that cost of compressing station fuel and operating cost are the same and that pipe-line operating costs and management costs are 10 percent higher. Reconstruct the table given on page 177 and the break-even chart, Figure 48.

9. In the case of the silk mill referred to (page 178), prepare a table of mill allowances for indirect labor, indirect supplies, machine repairs, miscellaneous expense, and power as well as the total of these, for 20, 40, 60, 80 and 100 percent activity. The data of Figure 49 is to be used in preparing this table.

Referring to the data given on page 155:

Problem 10. Construct the break-even charts (annual basis) for each product and for the business as a whole.

Problem 11. Construct the break-even charts of each territorial division to carry its own expenses from the data on page 158 and verify the expense trends and break-even points which follow.

Problem 12. Construct the break-even charts of each division to carry its own expenses plus its portion of manufacturing and administrative expense from the data on page 159 and verify the break-even points stated in the text.

CHAPTER VIII

1. What sum of money invested at 4 percent simple interest will amount to $1,000 in 5 years?

2. If the sum determined above were invested for 5 years at 4 percent interest, compounded annually, what would the compounded amount be?

3. If you had promised to pay $10,000 at the end of 15 years with interest compounded annually at the rate of 5 percent, what sum of

money compounded annually at the rate of 3 percent would have to be deposited today to meet this obligation?

4. A young man, 20 years of age, has a legacy of $100,000 to be paid him at the age of 30 years. He wishes to spend the next 7 years in acquiring a medical education which he estimates will cost him $2,500 per year. Each year, beginning at the age of 20, he sells part of his legacy on a 6% present worth basis to realize $2,500 to defray his expenses. How much will his equity in the legacy be when he becomes 30 years of age?

5. A manufacturer wishes to expand his business for which he needs $100,000. He obtains the loan from a private person on the following basis. Because of the speculative features of the business, the lender wants 8 percent on his money compounded annually and to be paid in 10 years. As further protection he requires the borrower to make monthly deposits in a savings bank at 3 percent compounded annual interest so that the savings bank fund will equal the amount he is to be paid at the maturity of his loan. How much must the annual savings deposits be?

6. How much should you pay for an apartment house on the basis of the following data? Anticipated net monthly income (rent − expenses) $5,000. Estimated resale value at end of 15 years $50,000. Net monthly incomes assumed to be deposited at 4 percent compound annual interest. Return on investment 8 percent.

7. What sum of money, invested now at 4 percent interest compounded semiannually, will be just sufficient to pay $1,000 two years from now, $1,000 four years from now, $1,000 six years from now, and $1,000 eight years from now?

8. A man has a savings account in a bank which pays 3 percent interest compounded annually. He opened his account with a deposit of $3,000, and no deposits or withdrawals have been made since. If his balance is now $13,380, how long ago did he open the account?

9. With interest at 5 percent compounded annually, how much money could be borrowed today to be completely repaid by a payment of $500 five years from now and $500 ten years from now.

10. A manufacturer estimates that by the use of a new piece of equipment he can save $1,000 per year in operating costs, including capital recovery through depreciation. The life of the equipment is estimated to be 5 years. On the basis of 3 percent interest on savings and 7 percent interest on the investment, what is the top price he can afford to pay for the equipment?

CHAPTER IX

1. A machine purchased for $10,000 is estimated to have a useful life of 15 years. Plot the book value of the machine for each year of its expected life, according to each of the following methods for accounting for depreciation:

a. Straight line
b. Sinking fund at 4 percent
c. Diminishing balance with a scrap value of \$2,000 at the end of 15 years.

2. A company pays \$75,000 for a diesel engine for its power plant. Freight and haulage amount to \$2,000 and installation in the plant costs \$5,000. The estimated life of the engine is 20 years and the salvage value at that time is estimated to be \$4,000. Find the book value at the end of each year of its life, using:

   a. Straight-line depreciation
   b. A 3 percent sinking fund
   c. Diminishing balance depreciation.

3. Determine the charge of the cost of production for each year for each of the above methods.

4. If a machine costing \$5,000 in 1938 is to be replaced in 1948, but at a cost of \$7,500, how much should be charged to depreciation each year by the straight-line method? Why?

5. What is the reason that the Government allows only that rate of depreciation which will permit of the recovery of the original investment?

6. What arguments would you present to the Government in asking for capital recovery in 5 years when the table of useful life preferred by the Government is 10 years? Illustrate by reference to a particular type of asset.

7. What justification is there for charging annual depreciation according to the volume of annual sales?

8. Why are bondholders interested in having a company use high rates of depreciation while stockholders favor low rates?

9. The total cost to a company of a new lathe, installed and ready to operate, is \$8,000. It is estimated that this machine can be sold for \$500 at the end of 15 years. Determine the yearly depreciation charge, the total depreciation, and the book value at the end of the fifth year by means of the straight-line method.

10. A manufacturing company is in the market for a machine to fabricate one of its products. The piece may be made on a turret lathe at a cost of 12¢. The turret lathe would cost \$4,500 and its expected life is 10 years, with a \$500 salvage value at that time.

    The product can also be made on an automatic screw machine at a unit cost of 10¢. This machine is priced at \$7,500 and it is expected to last 15 years with no scrap value.

    If the annual output of the plant is 10,000 pieces, which machine would you recommend to the company if a straight-line depreciation system were used?

    How would your decision be affected if a 6 percent sinking fund were used instead?

11. A truck costs $2,500 when new and its life expectancy is 8 years. It is anticipated that its scrap value will be $200. By means of the diminishing balance method, calculate the depreciation charge for the sixth year and the book value at the end of that year.

CHAPTER X

1. Classify the types of labor (direct or indirect) engaged in the following operations:

   a. Operating a milling machine in a toolroom
   b. Operating a comptometer in the accounting office of a factory
   c. Operating a paint spray machine in an auto-body works
   d. Oiling the line shaft bearings
   e. Operating a punch press in a structural iron works.

2. Classify the type of material (direct or indirect) used for the following purposes:

   a. Varnish to finish furniture
   b. Tool steel for making lathe tools
   c. Coal for the factory power plant
   d. Coal for a heating furnace in a forge shop
   e. Gears purchased for use in the product sold.

3. In what division of expense does each of the following belong?

   a. Foreman's salary
   b. Fire insurance on factory
   c. Insurance on life of the president
   d. Depreciation on delivery equipment of sales division
   e. Service of a consultant on factory wage system.

4. A manufacturer has three items of inventory of materials purchased at prices as indicated below.

Date	Material	Amount Pounds	Purchase Price per Pound
Aug. 11	A	500	10¢
Oct. 20	A	1,000	12¢
Sept. 7	B	600	20¢
Nov. 11	B	800	23¢
Oct. 30	C	900	32¢
Nov. 20	C	1,500	35¢

During December the quantities of materials costed into the products sold are as follows:

Material A	1,200 lbs
B	500 "
C	2,000 "

At what costs will the materials A, B, and C be entered into the cost of manufacture for December by each of the following methods: (a) Average cost, (b) FIFO, and (c) LIFO?
Which of these are readily acceptable to the Federal tax authorities? Why would any company use a method not readily acceptable to the Federal tax authorities? What problem of accounting arises in the use of non-acceptable methods?

CHAPTER XI

1. Referring to Figure 57, show, to twice the size, the costs of processing for the month of August from the following data:

Material cost	2.87¢ per lb.
Mashing	0.88¢ " "
Fermenting	1.47 " "
Separating	0.60 " "
Pressing	0.80 " "
Packing	2.25 " "
Direct labor	0.85 " "
Operating supplies	0.12 " "
Repairs production department	0.40 " "
Steam	0.65 " "
Electric power	0.70 " "
Refrigeration	0.18 " "
General and fixed charges	0.84 " "
Packing cost at plant	1.54 " "
Packing cost at cutting	0.72 " "

2. In a given process industry the materials pass through seven major processes, which are designated

A, B, C, D, E, F, and G.

The following facts have been established concerning each major process.

ITEM	Major Processes A	B	C	D	E	F	G
	Percent of Total						
Floor space	10	15	5	20	5	15	30
Value of equipment	5	20	10	25	10	10	20
Power consumed	15	5	10	10	15	20	25
Labor (indirect)	10	15	5	15	10	15	30
Supplies	15	15	15	10	15	15	15

The annual depreciation, insurance, and taxes on the building total $150,000. The annual depreciation, insurance, and taxes on equipment

total $320,000. The monthly power bill averages $10,000. The monthly (indirect) labor payroll is $30,000. Supplies cost $1,500 per month. Heating and lighting averages $3,000 per month.

Determine the monthly amounts of each item and the totals of the above factory expense for each major process, and for the plant as a whole.

3. The records of a certain manufacturing company for a given month show the following:

Cost of manufacture	
Materials	$45,000
Labor (direct)	20,000
Factory expense	20,000
Direct-labor-hours	16,000

Product X incurs a material cost of $2.00 and a labor cost of $4.00 in 4 labor-hours. What is the estimated cost of manufacture by the direct-labor-hour method from the above facts?

4. In the above example a more detailed examination of factory expense and direct-labor-hours shows the following:

		Department			
	Total	1	2	3	4
Factory expense	$20,000	5,000	10,000	2,000	3,000
Direct-labor-hours	16,000	4,000	6,000	4,000	2,000

Product X is worked on for 3 hours in Department 2 and one hour in Department 4. What is the estimated cost of manufacture by the direct labor hour method from the above facts?

5. The business to which Table XLII, page 269, relates, finds that, due to rising costs, the following increases are had in each of the following items: taxes 10%, insurance 5%, labor 30%, materials 40%, supervision 25%, depreciation no change, all service departments 25%. The distribution to the productive departments is unchanged. The direct-labor-hours and their distribution by departments are also unchanged. Determine the new hourly rate for each productive department and for the factory as a whole.

6. A manufacturer uses the percentage on wages method for allocating factory expense. Selecting appropriate data showing that the four departments of his business have widely different factory expenses and direct-labor-hours, write him a letter in justification of the use of departmental factory expense allocation by direct-labor-hours.

7. Explain what is meant by a compound business. Illustrate by an example, and suggest what steps should be taken to allocate properly the expenses of the business.

8. A manufacturer accounts for depreciation as a single account and as a deduction from gross profit. He now wishes to have it allocated as part of the cost of manufacture. Assuming the appropriate data for illustrative purposes, write a letter to an assistant instructing him how to make such an allocation.

9. A certain company houses its factory and administrative and sales offices in one building. The factory occupies 90 percent of the floor space, and sales and administration occupy 10 percent. In the factory, 75 percent of its space is occupied by productive departments and 25 percent by service departments. The power plant provides heat, light, and power and is housed in a separate building. Fifty percent of its output is used to provide power to operate the factory. The other 50 percent of output is used to light and heat the entire building.

   Set up a table of distribution of the cost of light, heat, and power to the factory and its productive and service departments, and to the administrative and sales offices.

10. A certain company maintains an engineering and drafting department which makes designs and blueprints for use in production, and also makes designs and blueprints for the tool department and the pattern shop. The question arises as to how much of the annual cost of maintaining the engineering and drafting department is to be charged to the tool department and how much to the pattern shop. Suggest a way for an equitable solution of this problem.

CHAPTER XII

1. A beet sugar mill is estimated to have constant total expenses of $1,500,000 per annum. Its capacity is 250,000 tons of beets per annum. The yield is 230 pounds of sugar per ton, and pulp and molasses which sell for $450,000 per annum. The variable total expenses for full capacity operations are $1,600,000. Crediting pulp and molasses sales to reduction of operating costs, what is the constant unit cost per ton? What are the variable unit costs and the total cost per ton for from 40 to 100 percent capacity operation? Graph the data on costs.

2. A certain automobile manufacturing company produces automobiles at a yearly total expense of $100,000,000 plus 75 percent of sales. Its automobiles sell to the dealer for $1,250 each. Its maximum capacity is 1,200,000 automobiles per annum. What is the cost per automobile for from 40 to 100 percent capacity operations?

3. A certain machine costs $10,000 and has an estimated useful life of 5 years. Insurance and taxes are at the rate of 3 percent each. It is operated by a workman who receives $1.50 per hour. The machine can do a particular operation at a maximum rate of 10 per hour. The shop operates for 2,000 hours per year. Determine the cost per operation

for from 20,000 to 5,000 operations per year under each of the following conditions:

a. Machine always run at maximum capacity; workman assigned to other jobs when the machine is idle
b. Machine always run at maximum capacity; machine adjusted to perform other operations when the above particular operation is not being performed.

Graph the results in each case.

4. A certain manufacturer has the problem of producing 30,000 parts annually and to select the most economic lot size to be equally spaced during the year. The annual cost of housing the average inventory and the interest on the investment in inventory when the whole annual requirements are produced in one run is $1,000. The cost to set up and dismantle the machine plus other service incidental to starting a production order is $25. What is the economic lot size?

5. Why do not the cost to possess and the cost to operate appear as factors in the determination of the best lot size, except, of course, as these costs enter into the value of inventory?

6. Plot values z, r, and z + r in the above example for value of k from 1 to 12. Compare the minimum ordinate of the plotted data with the results obtained in Problem 4.

CHAPTER XIII

1. Two lathes (A and B) compare as follows:

Prices	A = $2,750	
	B = $3,200	
Speeds	A	360, 300, 180, 90, 60
	B	300, 190, 100, 40, 12
Torques	A	2, 2.5, 4, 8, 15
Foot pounds	B	1.5, 2, 3.5, 10, 18

Lay out the torque-speed diagram of each lathe. Let the area of Diagram A = 1. How do the prices compare in terms of power-capacity?

2. A 1,000 hp steam turbine is purchased on a guaranteed performance of 11 pounds of steam per hphr. at rated load. Upon test, the steam consumption is found to be 12⅛ pounds per hphr. at rated load. The cost of steam is 14¢ per 1,000 pounds. The turbine is estimated to have a life of 15 years and to operate for 3,000 hrs. per year. On the basis of interest at 4 percent, what adjustment in price would compensate the purchaser?

3. A purchaser must decide between two machine tools, each of which is capable of doing the required job. They compare as follows:

	Machine A	Machine B
Investment	$5,000	$8,000
Annual percentage of fixed charges	12%	18%
Hourly wages	$1.25	$1.10
Hourly service charge	$1.00	$1.00
Pieces produced per hour	6	9
Annual shop hours	2,000	2,000

Which machines will give the lower cost per unit of output for both machines operating continuously throughout the year?

4. If, in the above example, the machines could not be used on any other kind of work, and the annual production to which they are adapted is 6,000 pieces, which then would give the lower cost per piece?

5. Power may be provided for a factory by a steam plant, a diesel engine plant, or through purchased power and the use of a motor. The capacity is to be 1,200 hp and the plant is to operate 4,000 hrs. per year. The proposals compare as follows.

	Steam	Diesel	Motor
Investment	$90,000	$150,000	$12,000
Fixed charges in percent	16	18	15
Labor and service cost including fuel per hphr.	1.1¢	0.8¢	1.5¢
Estimated life	20 yrs.	12 yrs.	25 yrs.

The motor has an efficiency of 92 percent. Which is the best investment and why?

6. A certain job in a factory is performed by the use of several very simple jigs. It requires 4 hours to do the work and the labor cost is $1.25 per hour. Two thousand pieces per year are required. It is proposed to design and build a more complicated jig for this job, which, it is estimated, will allow the job to be done in 2 hours at a labor cost of $1.00 per hour. The jig will cost $1,000 and carry an annual cost for depreciation, repairs, etc., of 60 percent. The service charge on labor will be 100 percent in each case. Will it pay to construct the jigs and, if so, what annual saving will result? Below what annual production will it not pay to construct the jig?

7. If the rod packing data of Table A, page 320, had been as follows, what would the work value cost per hour of service have been?

Sample	Weight Req. Pounds	Price	Total Service Hours	Friction HP
A	2.90	$1.20	1,500	1.00
B	2.00	1.20	1,400	1.25
C	2.60	1.20	500	1.20
D	3.20	1.20	900	1.40
E	3.00	1.20	1,200	1.60

8. If the bid price of the packing in each case were as follows, what would be the service cost per hour?

Sample	Bid Price
A	$0.85
B	0.95
C	0.87
D	0.98
E	1.00

9. If, in Table D, page 322, the bid price per crucible had been as follows, what would have been the service cost of crucible per hour in each case?

Bid	Bid Price per Crucible
A	$11.50
B	7.30
C	7.40
D	8.50
E	8.20
F	6.10

10. Two manufacturers of turbines bid on an installation of 750 hp. The one guarantees a steam consumption of 13 pounds per hphr., at rated load, the other 12½ pounds. If the cost of steam is 15¢ per 1,000 pounds and each turbine is estimated to have a life of 20 years and to operate 3,000 hours each year, what additional price can the purchaser afford to pay for the more economical turbine on the basis of 6 percent interest?

11. An alumnus decides to present his alma mater with a new power plant and to establish an endowment for its operation and maintenance by giving the college some 6 percent bonds. What should be the total face value of the bonds under the following circumstances: The power station is to be a 1,500-hp steam electric plant costing $125 per hp. The average operating cost is 0.5¢ per hphr., and insurance and depreciation are estimated to be 6½ percent annually. There are no taxes to be paid. The estimated useful life of the plant is 20 years. The plant will run practically continuously for 9 months in the year.

12. The proprietor of a small machine shop has $10,000 available for capital investment in his business. He finds that two opportunities present themselves:
    a. To buy a machine for $8,000, which will reduce the cost of manufacture of a certain product 10¢ per piece at the current annual output of 15,000 pieces, which is the capacity of the machine to be replaced. The machine can produce 25,000 pieces annually at a reduction in cost of 12¢ per piece. If he reduces his selling price 3¢, he can increase his annual sales from 15,000 to 25,000 and make a profit of 16¢ per piece. He can invest the remaining $2,000 at 6 percent interest. The investment in the machine to be replaced has been fully recovered through depreciation charges, and has no

scrap value. The new machine has an annual production capacity of 35,000 pieces.

b. To revamp his power plant at a cost of $10,000 and save $3,000 per year, provided the cost of fuel remains unchanged.

Which is the better investment?

CHAPTER XIV

1. Referring to the discussion on page 338, why is it said that the case of "issuing certificates or claims to goods not paralleled by the production of goods" is "bringing us nearer to an understanding of what is happening in our economy." Do you agree or disagree with this statement? Why?
2. On December 31, 1947, the index of retail food prices was 206.9 (1935–1939 =100). Does this increase indicate a fluctuation in prices of retailed food or a variation in the value of the dollar? Why?
3. What is the most generally used form of money in the United States today: is it gold currency, paper currency, or bank credits?
4. After 1945, the total amount of bank-held Government securities declined. What was the effect on the trend of total money supply? Does this decline in bank-held Government securities after 1945 indicate more inflation, or less inflation?
5. Why are so many businessmen concerned about the replacement value of their fixed assets in times of inflation?

CHAPTER XV

1. Define "effective demand." What is the difference between customers' needs and customers' effective demand?
2. If you were manufacturing goods for seven-year-olds, would you expect a substantial increase of your market in 1954? Why?
3. If you need a reliable forecast of the United States population in 1960, can you find it? Where?
4. Is it probable that the rate of increase of the United States population in the coming fifty years will be comparable to its rate of increase during the last fifty years? Does it matter? Why?
5. What is the difference between cash sales and instalment sales? Are instalment sales sometimes dangerous for the national economy? If so, when and why?
6. The annual department stores sales and disposable annual incomes in the United States were as follows for the period 1929–1946 (selected years— Source: *Statistical Abstract of the U.S.*, 1947):

	Department Stores Sales	Disposable Income
	(*Billions of Dollars*)	
1929	4.350	82.484
33	2.538	45.165
35	3.311	57.973
39	3.975	70.167
41	5.027	92.015
42	5.566	116.197
43	6.132	131.617
44	6.764	145.574
45	7.428	149.430
46	9.650	159.176

a. Plot these sales in relation to disposable income.
b. Is there a definite trend and, if so, what is its meaning?

7. a. What is the "available income of a customer in regard to a given product"? Illustrate by a few examples
   b. Why is the available income a "subjective" evaluation? What about the "disposable income"? Illustrate by an example.

8. Why, in your opinion, was the regulation restricting consumer credits (Regulation "W"), which ended soon after the war, reinstated in 1948?
   Why is consumer credit at all permitted by law? What would happen if it were not?

9. Under what circumstances would you, as a manufacturer, apply for credit insurance?

Year	Disposable Personal Income	All Stores	Non-Durable Goods	Durable Goods
		(*Billions of Dollars*)		
1933	45.16	24.51	19.67	4.84
35	57.97	32.79	25.16	7.62
36	66.09	38.33	28.47	9.96
37	71.05	42.15	31.07	11.07
38	65.46	38.05	29.46	8.59
39	70.16	42.04	31.66	10.37
40	75.74	46.38	33.97	12.41
41	92.01	55.49	39.88	15.60
42	116.19	57.63	47.36	10.27
43	131.61	63.72	53.96	9.75
44	145.57	69.57	59.10	10.46
45	149.43	76.64	64.68	11.96
46	159.17	100.78	79.02	21.76
47	173.57	118.32	87.93	30.39

10. The preceding data are taken from the *Survey of Current Business,* published by the United States Department of Commerce (July, September, 1948).
    a. Plot the sales of all retail stores against disposable personal income and derive the equation of trend
    b. Same for non-durable goods stores
    c. Same for durable goods stores.

CHAPTER XVI

1. It has been said that the elimination of the use of basing points will force a relocation of many plants.
    a. Would you say that it may be true for plants producing cement? Why?
    b. Would you say that it may be true for steel mills? Why?
    c. Would you say that it may be true for automobile manufacturers? Why?

2. During the period 1825–1945, the coal production (in thousands of short tons) varied as follows in the United States (source: *Statistical Abstract of the United States*):

1825	141	1905	339,357
35	1,032	15	529,189
45	4,535	20	658,265
55	12,513	25	581,870
65	20,538	30	536,911
75	52,179	35	424,532
85	107,291	40	512,257
95	178,822	45	630,934

Using the above data, plot the growth curve of the coal mining industry in the United States. Compare with the growth curve of the automobile industry (Figure 81, page 405). Comment.

3. If, in a given industry, the new customers' market decreases very substantially, is this a factor that might encourage the industry to reduce the quality of its production?

4. What is the most favorable stage in a given industry's expansion for standardization to begin? Why?

5. Has standardization already begun on a large scale in the automobile industry? Why?

6. Did not standardization begin at an early stage in the typewriter industry? Why?

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